DOCUMENT RESUME

ED 241 695	CE 038 362

AUTHOR	Jones, Jimmie L.
TITLE	Entomology Specialist 1-1. Military Curriculum Materials for Vocational and Technical Education.
INSTITUTION	Air Force Training Command, Sheppard AFB, Tex.; Ohio State Univ., Columbus. National Center for Research in Vocational Education.
PUB DATE	77
NOTE	644p.
PUB TYPE	Guides - Classroom Use - Materials (For Learner) (051)
EDRS PRICE	MF03/PC26 Plus Postage.
DESCRIPTORS	Behavioral Objectives; Course Content; Disease Control; *Entomology; Environmental Standards; *Equipment; First Aid; Hand Tools; Herbicides; High Schools; Individualized Instruction; Insecticides; *Job Skills; Job Training; Learning Activities; *Occupational Information; Occupational Safety and Health; *Pesticides; *Pests; Postsecondary Education; Programed Instructional Materials; Rats; Supervision; Technical Education; Test Items; Vocational Education; Workbooks
IDENTIFIERS	Military Curriculum Project

ABSTRACT

This individualized, self-paced course for training an entomology specialist was adapted from military curriculum materials for use in vocational and technical education. Completion of the course should provide students with basic information needed to accomplish the following duties of an entomology specialist: perform entomological work, apply toxic pesticides, perform control operations and preventive operations, operate and calibrate dispersal and safety equipment, maintain tools and equipment, and supervise entomology personnel. The document consists of a student workbook with objectives, assignments, review exercises and answers, volume review exercises, and a test. The workbook consists of six volumes. The first volume introduces pest management and safety, while the second contains information about pesticides and the environment and pesticide dispersal equipment. In the third volume, pests carried by domestic animals are discussed, while in the fourth household pests such as spiders and reptiles are examined. The final chapters provide information on the collection, identification, and control of economic pests (such as stored product pests, structural pests, and ornamental and turf pests) and vertebrate and vegetative pests (rodents, bats, birds, aquatic plants, grasses, and herbaceous broadleaf plants). The course in intended for use in a laboratory or on-the-job learning situation. (KC)

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MILITARY CURRICULUM MATERIALS

The military-developed curriculum materials in this course package were selected by the National Center for Research in Vocational Education Military Curriculum Project for dissemination to the six regional Curriculum Coordination Centers and other instructional materials agencies. The purpose of disseminating these courses was to make curriculum materials developed by the military more accessible to vocational educators in the civilian setting.

The course materials were acquired, evaluated by project staff and practitioners in the field, and prepared for dissemination. Materials which were specific to the military were deleted, copyrighted materials were either omitted or approval for their use was obtained. These course packages contain curriculum resource materials which can be adapted to support vocational instruction and curriculum development.

The National Center Mission Statement

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- Evaluating individual program needs and outcomes
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FOR FURTHER INFORMATION ABOUT
Military Curriculum Materials
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The National Center for Research in Vocational Education
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Military Curriculum Materials for Vocational and Technical Education

Information and Field
Services Division

The National Center for Research
in Vocational Education

ilitary urriculum Materials issemination Is . . .

activity to increase the accessibility of litary developed curriculum materials to cational and technical educators.

is project, funded by the U.S. Office of ucation, includes the identification and quisition of curriculum materials in print m from the Coast Guard, Air Force, my, Marine Corps and Navy.

cess to military curriculum materials is ovided through a "Joint Memorandum of derstanding" between the U.S. Office of ucation and the Department of Defense.

e acquired materials are reviewed by staff l subject matter specialists, and courses emed applicable to vocational and tech- cal education are selected for dissemination.

e National Center for Research in cational Education is the U.S. Office of ucation's designated representative to quire the materials and conduct the project ivities.

oject Staff:

Wesley E. Budke, Ph.D., Director
National Center Clearinghouse

Shirley A. Chase, Ph.D.
Project Director

What Materials Are Available?

One hundred twenty courses on microfiche (thirteen in paper form) and descriptions of each have been provided to the vocational Curriculum Coordination Centers and other instructional materials agencies for dissemination.

Course materials include programmed instruction, curriculum outlines, instructor guides, student workbooks and technical manuals.

The 120 courses represent the following sixteen vocational subject areas:

- Agriculture
- Aviation
- Building & Construction Trades
- Clerical Occupations
- Communications
- Drafting
- Electronics
- Engine Mechanics
- Food Service
- Health
- Heating & Air Conditioning
- Machine Shop
- Management & Supervision
- Meteorology & Navigation
- Photography
- Public Service

The number of courses and the subject areas represented will expand as additional materials with application to vocational and technical education are identified and selected for dissemination.

How Can These Materials Be Obtained?

Contact the Curriculum Coordination Center in your region for information on obtaining materials (e.g., availability and cost). They will respond to your request directly or refer you to an instructional materials agency closer to you.

CURRICULUM COORDINATION CENTERS

EAST CENTRAL
Rebecca S. Douglass
Director
100 North First Street
Springfield, IL 62777
217/782-0759

MIDWEST
Robert Patton
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1515 West Sixth Ave.
Stillwater, OK 74704
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ENTOMOLOGY SPECIALIST

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Volume 8 General Contingency Responsibilities - Deleted Page 670

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Developed by:

United States Air Force

Development and Review Dates:

August 1974

Occupational Area:

Agriculture

Cost: $68.10 ~~XXXXX~~

Print Pages: 681 ~~XXX~~

Availability:

Military Curriculum Project, The Center for Vocational Education, 1960 Kenny Rd., Columbus, OH 43210

Suggested Background:

None

Target Audiences:

Grades 10-adult

Organization of Materials:

Student workbook with objectives, assignments, review exercises and answers, and volume review exercises; test

Type of Instruction:

Individualized, self-paced

Type of Materials:			No. of Pages:	Average Completion Time:
Volume 1	-	~~XXXXXXXXXXXXXXXXX~~ Introduction to Civil Engineering	~~152~~ 1	Flexible
		~~XXXXXXXX~~	~~38~~	
~~XXXXXXXXXXXXXXXX~~			~~12~~	
Volume 2	-	Introduction to Pest Management	194	Flexible
Volume 3	-	Pest Management, Chemicals, and Equipment	92	Flexible
Volume 4	-	Disease Vectors and Pests of Domestic Animals	80	Flexible
Volume 5	-	Household Pests, Venonous Arthropods, and Reptiles	62	Flexible
Volume 6	-	Collection, Identification, and Control of Important Pests	60	Flexible
Volume 7	-	Collection, Identification, and Control of Important Vertebrate and Vegetative Pests	79	Flexible
Volume 8	-	General Contingency Responsibilities Deleted	1	
Change Supplement			9	

Supplementary Materials Required:

None

Course Description:

This course was designed to provide the student with basic information needed to accomplish the following duties of an Entomology Specialist:

- Performs entomological work
- Applies toxic pesticides
- Performs control operations
- Performs preventive operations
- Operates and calibrates dispersal and safety equipment
- Maintains tools and equipment
- Supervises entomology personnel

This course contains ~~one~~ 8 volumes ~~with eight chapters.~~ ~~The~~ [illegible] Volumes ~~Chapters~~ 1-8 contain information on specific military procedures and forms and were deleted. The remaining ~~chapters~~ volumes are described below.

SEE ATTACHED

Objectives, readings, and review exercises with answers for student self-study and evaluation are included for each chapter. A volume review exercise is available, but the answers are not given. This course was designed to provide basic information on entomology control and equipment. It would best be used in a laboratory or on-the-job learning situation.

Volume 2 - Introduction to Pest Management provides knowledge about the following subjects: introduction to entomology; pest management planning and coordination; and safety, protective equipment, and first aid.

Volume 3 - Pest Management, Chemicals and Equipment provides knowledge about the following subjects: pesticides and environment, and pesticide dispersal equipment.

Volume 4 - Disease Vectors and Pests of Domestic Animals discusses the many arthropods that carry diseases to humans and domestic animals, as well as those generally considered to be pests.

Volume 5 - Household Pests, Venomous Arthropods, and Reptiles discusses venomous arthropods and reptiles as well as some signiqicant household pests.

Volume 6 - Collection, Identification, and Control of Important Economic Pests provides knowledge concerning the more important economic pests, which include stored product pests, structural pests, and ornamental and turf pests.

Volume 7 - Collection, Identification, and Control of Important Vertebrate and Vegetative Pests provides knowledge concerning the more important vertebrate and vegetative pets which includes domestic and field rodents, bats, birds, aquatic plants, grasses, and herbacious broadleaf plants.

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MODIFICATIONS

Volume 1 OF THIS PUBLICATION HAS (HAVE) BEEN DELETED. THIS MATERIAL USES MILITARY FORMS, PROCEDURES, SYSTEMS, ETC. AND IS NOT CONSIDERED APPROPRIATE FOR USE IN VOCATIONAL AND TECHNICAL EDUCATION.

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CDC 56650

ENTOMOLOGY SPECIALIST

(AFSC 56650)

Volume 2

Introduction to Pest Management

Extension Course Institute

Air University

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DEPARTMENT OF THE AIR FORCE
MCMXLVII
UNITED STATES OF AMERICA

PREPARED BY
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EXTENSION COURSE INSTITUTE, GUNTER AIR FORCE STATION, ALABAMA

THIS PUBLICATION HAS BEEN REVIEWED AND APPROVED BY COMPETENT PERSONNEL OF THE PREPARING COMMAND IN ACCORDANCE WITH CURRENT DIRECTIVES ON DOCTRINE, POLICY, ESSENTIALITY, PROPRIETY, AND QUALITY.

Preface

THIS VOLUME of CDC 56650, *Entomology Specialist*, provides you with knowledge about the following subjects: introduction to entomology; pest management planning and coordination; and safety, protective equipment, and first aid. To become certified as an entomology specialist, you must be knowledgeable in these subjects as well as those that you will cover in later volumes.

Please note that in this volume, we are using the singular pronoun *he, his,* or *him* in its generic sense, not its masculine sense. The word to which it refers is *person.*

If you have questions on the accuracy or currency of the subject matter of this text, or recommendations for its improvement, send them to Tech Tng Cen/TTGOX, Sheppard AFB TX 76311. NOTE: Do not use the suggestion program to submit corrections for typographical or other errors.

If you have questions on course enrollment or administration, or on any of ECI's instructional aids (Your Key to Career Development, Behavioral Objective Exercises, Volume Review Exercise, and Course Examination), consult your education officer, training officer, or NCO, as appropriate. If he can't answer your questions, send them to ECI, Gunter AFS AL 36118, preferably on ECI Form 17, Student Request for Assistance.

This volume is valued at 33 hours (11 points).

Material in this volume is technically accurate, adequate, and current as of May 1977.

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SUPPLEMENTARY MATERIAL

CDC 56650

ENTOMOLOGY SPECIALIST

(AFSC 56650)

Appendixes A and B and C

NOTE: This supplement is for use with Volumes 3 4, 5, 6, and 7.

Proficimus More Irretenti

Extension Course Institute

Air University

APPENDIXES

Appendix A. Pesticide Recommendations

Appendix B. Identification Keys to Some Important
Arthropods, Reptiles, Birds, and Mammals

Appendix C. Integrated Pest Management methods

APPENDIX A
PESTICIDE RECOMMENDATIONS

NOTICE: RECOMMENDATIONS CONTAINED IN THIS SECTION ARE INTENDED AS A GUIDE ONLY AND MUST NOT BE SUBSTITUTED FOR INFORMATION ON LABELS.

The Federal Insecticide, Fungicide, and Rodenticide Act as amended by the Federal Environmental Pesticide Control Act of 1972 requires that all pesticide products be used according to the directions on product labels. Deviation from label directions is considered to be a violation of the Act, and individuals concerned are subject to civil or criminal actions. It is the responsibility of the user to ensure that a pesticide is used in a "common sense" manner and in compliance with the product label.

Periodic review and re-evaluation is conducted by the Environmental Protection Agency on each registered pesticide product to determine if the recommended uses will prevent undue hazard to the applicator and the occupants of treated areas, and adverse environmental effects. Only in very specific situations can a pesticide product be used in a manner which is inconsistent with the label directions and these exceptions must be recommended in writing by a knowledgeable expert. Within the Department of Defense this will be professional entomologists, or in the case of herbicides, it may include qualified agronomists.

The purpose of this section is to provide a general guideline to operations personnel. It should be recognized that with the frequency of changes in pesticide technology, particularly in the areas of formulation and application, the recommendations provided in the text of this manual may not be current. Wherever conflicts occur, the recommendations in this appendix (A) should be followed. The tables are not comprehensive lists of all materials or products registered for controlling the included pests. Neither the absence of pesticides from the tables, nor the order of arrangement of the pesticides should be construed as an endorsement of one product over another.

Strengths of finished formulations for many pesticides have not been listed in the tables. Current registration rules require dilution instructions to be included on pesticide labels. These instructions, when available, have been included in the tables in lieu of strengths expressed as percentages of the active ingredients.

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The abbreviations used in the tables include:

A.	aerosol	OS.	oil solution
Ac.	acre	P.	pellet
B.	bait	Pesticide-R.	proprietary pesticide
C.	crystals	R.	repellent
D.	dust	S.	solution
E.	emulsion	SC.	solution concentrate
EC.	emulsifiable concentrate	Su.	suspension
F.	fog	TBS.	tablespoon
Fm.	fumigant	tsp.	teaspoon
G.	granule	WP.	wettable powder
N/S	non-standard	SP.	soluble powder

TABLE A-1

Application of Insecticides

DO NOT SUBSTITUTE THESE RECOMMENDATIONS FOR INFORMATION ON LABELS

PEST-STAGE	LOCATION-TYPE OF TREATMENT	PESTICIDE/ STOCK STRENGTH/FORM			APPLICATION: STRENGTH, RATE, AND METHOD			REMARKS
			Percent		Percent			
Ant	Indoor-spot treatment	chlorpyrifos (Dursban-R.)	40.8	EC.	0.5	E.		Apply as a coarse spray or with a paint brush to areas where pests normally occur. Keep children and pets off treated areas until dry. Treatments in food handling area must conform to EPA standards.
		diazinon	47.5 48.7	EC. S.	0.5 0.5	E. OS.	(1¼ fl oz EC/1 gal water)	
		propoxur (Baygon-R.)	2.0	S.	1.0	S.		
		chlordane	5.0	D	5.0	D		Indoor dust must be placed where children an pets cannot reach it. NOTE: Chlordane, if available and labeled for ants, may be used.
	Outdoor-spot treatment	carbaryl	80.0	WP.	2.0	Su	1.0-1.25 lb actual/150-200 gal water/5,000 sq ft.	Apply to nest and in 6-inch bands around nests. Spot treat trails and points of entry.
		malathion	57.0	EC.	0.1	E.		Apply to mounds and saturate soil and mix with loose earth on top of mounds.
		chlordane	5.0	D	5.0	D		Outdoor dusts or granules must be watered into nests. NOTE Chlordane, if available and labeled for ants, may be used.
	Indoor-bait	Kepone-R. N/S	0.125	G.,B.	0.125	B.		Apply lightly near baseboards in closets, under sinks and refrigerators, and other areas where ants may be found but which are inaccessible to children.
		propoxur (Baygon-R.)	2.0	g., B.	2.0	B.		
Ant: Carpenter	In wood	propoxur (Baygon-R.)	1.0	S.	1.0	S.	Inject solution into galleries or nests.	CAUTION: Oil solutions may soak through wood and stain finished surfaces. Uses sparingly. Spot treat trails. Fumigation may be required (see Termites, drywood).
Ant: Imported fire	Mound application-bait	Mirex-R. N/S		B.		B.	0.02 grams actual/mound.	For pasture and cropland use only.
		Kepone-R N/S	0.125	G.,B.	0.125	B.		Place 1 or 2 tsp of paste, 1 or 2 tbs of granules within a few inches of mound entrance.
	Area-bait	Mirex-R. N/S		B.		B.	1.7 grams actual/Ac. on pastures and cropland. 3.4 grams actual/Ac. on golf courses, parks, lawns, ornamental turf, cemeteries.	Consult label. Broadcast application. No more than [illegible] applications in 12 months. Do not apply more than once over 30 day period.
Aphid	Residual-Outdoors on ornaments	malathion	57.0	EC.		E.	(2 tsp EC./gal or 1 qt EC./100 gal water)	Cover foliage thoroughly, including underside. Control nearby ants also, if they are tending aphids. Meta-Systox is toxic to fish and wildlife; keep out of lakes, streams and ponds. Apply dimethoate only to plants listed on label.
		Meta-Systox-R. N/S		EC.	0.05	E.	Refer to label for specific species and rates.	
		dimethoate N/S	23.4	EC.		E.	(2 tsp EC./gal or 1 qt EC./100 gal water)	
Armyworm	Area	carbaryl	80.0	WP.		Su.	1.0-1.25 actual/150-200 gal water/5,000 sq ft.	Apply to young plants and to soil when larvae are small.
Bagworm	Residual	malathion	57.0	EC.		E.	(2 tsp EC./gal or 1 qt EC./100 gal water)	Apply to foliage as needed in early spring. Hand pick bags any time. Repeat at 7-10 day intervals.
		chlorpyrifos (Dursban-R.)	40.8	EC.		E.	(0.25 fl oz/3 gal water)	

TABLE A-1 (Cont)

Application of Insecticides

DO NOT SUBSTITUTE THESE RECOMMENDATIONS FOR INFORMATION ON LABELS

PEST-STAGE	LOCATION-TYPE OF TREATMENT	PESTICIDE/ STOCK STRENGTH/FORM	APPLICATION: STRENGTH, RATE, AND METHOD	REMARKS
		Percent	Percent	
Bedbug	Residual-mattress	malathion 57.0 EC.	0.5-1.0 OS. (2-4 tsp EC./gal deodorized kerosene)	Very light application, do not soak mattress. Use grade A malathion. Never apply to cribs, treat only crib mattress; allow mattress to dry at least 4 hours; recover mattress before use.
		dichlorvos N/S EC.	0.5 E.	
	Bedsteads, baseboards, wall crevices	malathion 57.0 EC.	1.0 OS. (2-4 tsp EC./gal deodorized kerosene)	Apply generously to bed frames and woodwork with special care to wet all possible hiding places. Do not spray cribs. Use grade A malathion.
		dichlorvos N/S EC.	0.5 E.	
		pyrethrum N/S 20.0 C.	0.1-0.2 E. May be added to above to flush bedbugs from hiding places.	
See: Wasp, Hornet, Yellow Jacket	Nests, Indoor and Outdoor	carbaryl N/S 5.0 D.	5.0 D. (Indoors) heavy dust.	Apply at night, or in early morning when pests are least active. Control personnel should wear protective clothing, head nets, and gloves.
		propoxur 1.0 S. (Baygon-R.)	1.0 S.	
		resmethrin 0.15 SU. (pressurized can)	0.15 SU. Saturate nest with spray.	For use in pin-point application. Most effective and with least risk to applicator apply after dark when insects are contained and at rest. Protective clothing advised. Do not apply in areas where foods and foodstuffs are exposed or handled.
	Garbage cans	No pesticides registered.	Consult USDA.	
Beetle: Carpet, Black, Common, Furniture & Varied	Residual Indoors	malathion 57.0 EC.	3.0 E.	Treat periphery of carpets and areas of carpets not subject to traffic; treat inside of chest, drawers, closets, and other storage areas. Thorough coverage essential
		diazinon 47.0 EC.	0.5 E. (1¼ fl oz EC./gal water)	
		lindane N/S 20.0 EC. N/S 0.5 OS.	. E. (3.25 fl oz EC./gal water 0.5 OS.	Apply coarse mist spray along cracks and crevices, in corners, along baseboards and moldings, in closets and along carpet edges Repeat each 6 months.
	Material: goods such as woolens, draperies, blankets and upholstery	malathion 57.0 EC.	3.0 E. Grade A only	May be applied to surface area of carpeting Clean and brush articles prior to treatment Treat seams well. Repeat after laundering or dry cleaning.
	Enclosed Storage: Repellent	Paradichlorobenzene 100.0 C.	100.0 C. 1 lb/100 cu. ft.	Protects approximately one year in tightly sealed space.
	Fumigant	Methyl bromide: See clothes moths		

TABLE A-1 (Cont)

Application of Insecticides

DO NOT SUBSTITUTE THESE RECOMMENDATIONS FOR INFORMATION ON LABELS

PEST-STAGE	LOCATION-TYPE OF TREATMENT	PESTICIDE/ STOCK STRENGTH/FORM			APPLICATION: STRENGTH, RATE, AND METHOD			REMARKS
			Percent		Percent			
Beetle: Japanese, adult	Residual	malathion	57.0	EC.		E.	(2 tsp EC./gal water or 1 qt EC./100 gal water)	Apply as needed to foliage and flowers of ornamentals.
		carbaryl	80.0	WP.			(5 tsp WP./gal water or 1.0 lb actual/100 gal)	
	Aircraft: disinsection	carbaryl-DDT cartridge	42.5-42.5	D.		D.	1 or 2 gm/1,000 cu ft. Use 1-, 5-, or 13-gram cartridges according to inside size of cargo hold of aircraft. Dispense with modified carbon dioxide fire extinguisher and special adapter. Follow label directions exactly.	Use only under direction of U.S. Dept. of Agriculture or U.S. Dept. of Health, Education and Welfare quarantine officials, or certified Military Quarantine Inspector.
Beetle: Japanese, Larva	Residual in lawns and turf	diazinon - See Whitegrub: Outdoors: diazinon						
		Milky spore disease N/S					Cannot be used with insecticide.	Seek guidance from area or command entomologist.
Beetle: White Fringed, Larva	Residual	No pesticides registered						
Beetle: Woodboring Powder-pos (true-false Flat headed borer, Old house, & Wharf borer	Residual	lindane	12.0	OS.	0.5	OS.	Spray or brush 1 gal/100 sq. ft of as needed to saturate surface. Inject using oil can or syringe.	Repeat surface application until wood is saturated. In the absence of emergence holes, drill holes 18 inches apart for injection application. Use a light oil such as deodorized kerosene as diluent unless heavier oil is not objectionable. Trichlo benzene serves as a highly penetrating solvent.
		Pentachlorophenol	5.0	OS.	5.0	OS.		
	Dip treatment	lindane	12.0	OS.	0.5	OS.	Cold dip for pallets, lumber and other wood products.	Can be sprayed or brushed on. Dipping: Items must be submerged for thre minute period.
		pentachlorophenol	5.0	OS.	5.0	OS.		
	Fumigation	See Termites, Drywood						
		See Clothes moth, methyl bromide						
Biting Midge/ Punkies (Culicoides spp.)	Adulticide residual treatment outdoors	propoxur (Baygon-R.)	1.0	S.	1.0	S.		Treat infested areas thoroughly including foundations, patios, screens and around doors and windows. Do not treat lawns or other plants.
		propoxur N/S (Baygon-R.)	75.0	EC. WP.	4.5	E. Su.	(3/4 cup 75% WP./qt water	Apply as a coarse spray to runoff or with paint brush. Treat outside surfaces of buildings, porches, patios, screens and window and door frames. Thorough coverage is necessary for maximum control. Do not treat lawns or other plants.

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TABLE A-1 (Cont)

Application of Insecticides

DO NOT SUBSTITUTE THESE RECOMMENDATIONS FOR INFORMATION ON LABELS

PEST-STAGE	LOCATION-TYPE OF TREATMENT	PESTICIDE/ STOCK STRENGTH/FORM			APPLICATION: STRENGTH, RATE, AND METHOD			REMARKS
			Percent		Percent			
Biting Midge (Cont)	Adulticide space spray outdoors	naled	85.0	S.		E.,S.	0.02-0.05 lb actual/Ac.	Essentially same as for mosquito adults. Ground application by ULV or thermal fog generator. Dilute thermal fog solution with No. 2 fuel oil, diesel oil or other appropriate oil.
		naled N/S		EC.		E.	0.05-0.25 lb actual/Ac. Apply 0.5-2.0 gal finished spray/Ac.	Aerial application. Dilute in fuel oil, or odorless kerosene. Repeat as needed. Do not apply over shrimp producing areas.
						E.	0.1-0.25 lb actual/Ac.	Ground application by mist or non-thermal fog generator. Dilute in water, repeat as needed.
		dichlorvos	See Mosquito:		adult, Outdoor space treatment.			
		malathion	See Mosquito:		adult, Outdoor space treatment.			
		fenthion N/S				S.	0.08 lb actual/Ac.	Apply to fog generator over areas such as ponds, marshes, swamps, and areas with grass or heavy foliage.
	Larvicide	Abate-R. N/S	2.0	G.	2.0	G.	0.05-0.5 lb actual/Ac.	See label for specific rate for different application sites. Young shrimp in treated tidal waters will be killed at these application rates.
	Personal protection	diethyltoluamide	See Mosquito: adult, Personal protection					
Booklouse	Indoor residual	propoxur (Baygon-R.)	1.0	S.	1.0	S.		Treat infested areas around storage spaces and behind bookcases. Remove pets and fishbowls before treatment. Use only as a crack and crevice treatment in edible product areas.
	Fumigant	No pesticides registered						Consult area or command entomologist.
Box elder bug	Residual on ornamentals	carbaryl	80.0	WP.		Su.	1.0 lb actual/100 gal water.	Foliage application.
	Indoors	pyrethrins	1.0	S.	S.,OS.		(Dilute 1 part of concentration in 4 parts of water.) 1 gal finished spray/750 sq ft.	Apply as a coarse droplet surface spray. Spray where insects are usually found including walls, baseboard molding, doors, cabinets, shelves, etc. Remove pets, birds, and cover fish aquariums before spraying.
Centipede	Residual-in garden	diazinon	25.0	EC.		E.	15 fl oz EC./100 sq ft in sufficient water to obtain coverage.	Make application to soil surface as a broad cast spray prior to planting. Thoroughly mix into top 4-8 inches of soil.
Chinch bug	Turf, Lawn	carbaryl	80.0	WP.		Su.	1.0-1.25 lb actual/150-200 gal water/500 sq ft.	Lawn should be moist at time of application Apply full volume to insure good penetration. Keep out of any body of water. Do not apply when weather conditions favor drift from treated area.
		chlorpyrifos (Dursban-R.)	40.8	EC.		E.		
			1.0 N/S	G.	1.0	G.	1.0-1.5 lb actual/Ac.	

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TABLE A-1 (Cont)

Application of Insecticides

DO NOT SUBSTITUTE THESE RECOMMENDATIONS FOR INFORMATION ON LABELS

PEST-STAGE	LOCATION-TYPE OF TREATMENT	PESTICIDE/ STOCK STRENGTH/FORM			APPLICATION: STRENGTH, RATE, AND METHOD			REMARKS
			Percent		Percent			
Chinch bug (Cont)	Turf, Lawn (Cont)	diazinon	47.5	EC.		E.	(2 to 3 fl oz EC. or 3 to 6 fl oz EC./25 gal water) Apply 3 gal/1,000 sq ft.	Use higher strengths or rates for longer residual control and in lawns of dense growth.
		N/S	14.3	G.	14.3	G.	Apply 1/2 to 1 lb or 1 to 1 1/2 lb/1,000 sq ft.	

TABLE A-1 (Cont)

Application of Insecticides

DO NOT SUBSTITUTE THESE RECOMMENDATIONS FOR INFORMATION ON LABELS

PEST-STAGE	LOCATION-TYPE OF TREATMENT	PESTICIDE/ STOCK STRENGTH/FORM			APPLICATION: STRENGTH, RATE, AND METHOD			REMARKS
			Percent		Percent			
Chinch bug (cont)	Turf, lawn (cont)	Aspon-R. N/S	13.0	EC.		E.	10 2/3 fl oz EC./15 gal . water to treat 500 sq ft.	Water lawn well before treatment. Cover area in two directions. Keep children an pets off treated areas for 24 hours and until grass has completely dried.
Clothes moth: (all spp.)	Indoor residual on garments	Perthane-R. N/S			5.0	E.		Clean and brush articles prior to treatm Spray thoroughly but do not saturate. Al adequate ventilation. Dry clean or laund garments before use.
Plaster bagworm & carpet beetle infesting fibrous products	Indoor residual for non-fabric areas	malathion	57.0	EC.	3.0	E., OS.		Use grade A malathion. Apply to baseboard floors, behind radiators and other accumu tion areas, closet shelves and walls, and fested surface areas of carpeting.
	Fumigation	paradichlorobenzene crystals	100.0		100.0		crystals 1 lb/100 cu ft	Use in airtight container.
		methyl bromide & chloropicrin	100.0	Fm.	100.0	Fm.		For use only by personnel trained in fum gation. Consult label for dosage rates a precautions.
Cockroach	Bait	propoxur (Baygon-R.)	2.0	B.	2.0	B.	4 oz/1,000 sq ft.	Place in areas where cockroaches are numerous and tend to congregate. When applying in accessible areas, they shoul be placed on paper or other material tha will permit removal. Use only in areas i accessible to children and pets.
		Kepone-R. N/S	0.125	B.	0.125	B.	Use 2 or 3 teaspoons of paste, 2 or 3 tablespoons of granules or 2 or 3 containers per infested room.	
	Residual for indoor crack and crevice treatment	propoxur (Baygon-R.) N/S			1.1	E., OS	Only dust should be used around electrical connections.	Non-Food Areas: Apply by spray or brush floor, walls, ceilings or other infested areas. Food Preparation Areas: Limited to crack and crevice treatment only. Apply small amounts of chemical directly into crevic such as expansion joints, between equipm bases and floor, wall voids, junction of switch boxes, etc. Do not use as a space application.
		diazinon	47.5	EC.	1.0	E.	(2.5 fl oz EC./1 gal water.)	
			2.0	D.	2.0	D.		
		chlorpyrifos (Dursban-R.)	40.8	EC.	0.5	E.		
		malathion	57.0	EC.	3.0	E.		
		silica gel N/S (pyrethrum 10.0 piperonyl butoxide 10.0 silica (amorphous) gel 40.0)				D.		See Label.
(cont)	Non-residual spray: indoors	resmethrin N/S	2.0	EC.	0.25	E.	Prepare 1 gal of finished spray by adding 1 pt 2 fl oz EC./3 qts, 14 fl oz water. Apply 1 gal/ 750 sq ft.	Apply as a coarse spray to areas frequen by cockroaches.

TABLE A-1 (Cont)

Application of Insecticides

DO NOT SUBSTITUTE THESE RECOMMENDATIONS FOR INFORMATION ON LABELS

ST-STAGE	LOCATION-TYPE OF TREATMENT	PESTICIDE/ STOCK STRENGTH/FORM			APPLICATION: STRENGTH, RATE, AND METHOD			REMARKS
			Percent		Percent			
ckroach (cont)	Residual-Outdoors	propoxur (Baygon-R.)	1.0	S.	1.0	S.		Apply as a residual spray or by paint brush to surface of buildings, porches, screens, window and door frames, patios and garages.
	Space treatment, indoors	pyrethrins plus piperonyl butoxide and MGK 264-R as synergists		N/S	3-5.0		ultra low volume (ULV) application. Apply at rate of 1/2 oz/1,000 cu ft.	ULV treatment can only be used when area is unoccupied. Remove or refrigerate all exposed food. Extinguish all flames. Open all drawers, cabinets and provide access to wall and ceiling voids. Shut off all ventilation. Wear goggles and respirator. Minimum exposure time of one hour. Do not remain in treated room. Ventilate before reentry. Wash down all food preparation surfaces before use. Not to replace standard crack and crevice treatments.
icket: ouse & ield	Indoor-residual	propoxur (Baygon-R.)	1.0	S.	1.0	S.		Apply by spray or brush to floors, walls, ceiling and other infested zones of non-food areas. Limited to crack & crevice treatment in food preparation spaces. Avoid applying to ornamental plants. Keep children and pets out until dry.
		chlorpyrifos (Dursban-R.)	40.8	EC.	0.25-0.5	E.	0.115-0.117 lb actual/ 5,000 sq ft.	
		malathion	57.0	EC.	3.0	E., OS.		
	Indoor-baits	propoxur (Baygon-R.)	2.0	B.	2.0	B.	4 oz/1,000 sq ft.	See remarks under Cockroach Bait.
	Residual-Outdoors on lawns	propoxur (Baygon-R.)	1.0	E.	1.0	E.		To prevent cricket entry into buildings spray a 5 ft band on soil around the structure and on foundation wall to a height of 2-3 feet. Repeat as necessary. Keep children and pets from treated areas until spray dries.
		diazinon	47.5	EC.		E.	(4 fl oz EC./3 gal water) 3 gal/1,000 sq ft.	
icket: ole	Outdoor-residual	Kepone-R. N/S	0.125	B.	0.125	B.	0.1-0.2 lb actual/5,000 sq ft.	Apply bait evenly by mechanical spreader.
tworm	Outdoor-area residual							All treatments: Treat when pests first appear. Toxic to fish and wildlife. Do not allow into any body of water.
		chlorpyrifos (Dursban-R.)	40.8	EC.		E.	0.115 lb actual/5,000 sq ft.	On grass. Lawn should be moist at time of application.
			40.8	EC.		E.	0.5 lb actual/100 gal water.	Foliage application. Repeat at 7 to 10-day intervals.
		diazinon	47.5	EC.		E.	(4 fl oz EC./3 gal water.) 3 gal/1,000 sq ft.	On lawns.

TABLE A-1 (Cont)

Application of Insecticides

DO NOT SUBSTITUTE THESE RECOMMENDATIONS FOR INFORMATION ON LABELS

EST-STAGE	LOCATION-TYPE OF TREATMENT	PESTICIDE/ STOCK STRENGTH/FORM			APPLICATION: STRENGTH, RATE, AND METHOD			REMARKS
			Percent		Percent			
arwig	Outdoor-residual on lawns and ornamental turf	chlorpyrifos (Dursban-R.)	40.8	EC.		E.	0.115 lb actual/5,000 sq ft.	To prevent earwig entry into building spray 5 ft band on soil around structure as well as foundation wall to a height of 2-3 feet. Keep out of any body of water.
		propoxur (Baygon-R.)	1.0	S.	1.0	S.		
	Residual-indoors	propoxur (Baygon-R.)	1.0	S.	1.0	S.		Apply as a spray or brush to door & window sills, stoves, cracks and crevices. Use only as crack & crevice treatment in edible product areas.
e gnat: ippelates pp.	Residual-outdoors	No pesticides registered						
	Space treatment-outdoors	See section under outdoor space treatment for mosquito adults.						
	Space treatment-indoors	synergized pyrethrins	N/S		3.0	GS.	5 fl oz/1,000 cu ft.	Cover or remove exposed food and food handling surfaces. Close room and shut off all ventilation. Expose 1/2 hour. Do not remain in treated areas. Ventilate thoroughly before reentry. Wear goggles and respirator during treatment.
ll webworm	See tent caterpillar.							
rebrat	See silverfish propoxur recommendation.							
ea: Cat, og	Residual-indoors	carbaryl	N/S	D.	5.0	D.		Sprinkle lightly on floors, rugs and furniture. Remove with a vacuum cleaner after an hour or two.
		ronnel	N/S 2.5	EC.	1.0	E.	1 gal/1,000 sq ft.	Do not apply in edible product areas. Spray floors, walls, cracks, crevices, including animal sleeping quarters. Do not allow children or pets to contact treated surface until spray dries.
	Residual-outdoors	diazinon	47.5	EC.		E.	(1¼ fl oz EC./3 gal water.) 3 gal/1,000 sq ft.	To prevent entry into structures spray a 5 ft band around building as well as the foundation to a height of 2-3 feet.
		propoxur (Baygon-R.)	1.0	S.	1.0	S.		Apply as spray or with paint brush to surface of buildings, porches, screens, windows and doorsills, patios and garages.
		malathion	N/S 4.0	D.	4.0	D.	1-2 lb/1,000 sq ft.	Apply to pet quarters, yards, lawns. Repeat in 3-4 weeks if necessary. Do not expose kittens less than 4 weeks of age.
			57.0	EC.		E.	5 fl oz EC./gal/1,000 sq ft.	
		carbaryl	N/S	D.	5.0	D.	0.25-0.5 lb actual/5,000 sq ft.	
	Animal Treatment:	malathion	N/S 5.0	A.	5.0	A.	25-30 seconds/18-20 lb dog. 15 seconds/5-8 lb cat.	Spray from neck to tail, legs and under body. Repeat in 7 days. Wash hands after application.
ont)		NOTE: Consult licensed veterinarian or Veterinary Services Officer (if available).						

TABLE A-1 (Cont)

Application of Insecticides

DO NOT SUBSTITUTE THESE RECOMMENDATIONS FOR INFORMATION ON LABELS

PEST-STAGE	LOCATION-TYPE OF TREATMENT	PESTICIDE/ STOCK STRENGTH/FORM	APPLICATION: STRENGTH, RATE, AND METHOD	REMARKS
Flea: Cat, Dog (cont)	Animal Treatment: (cont) Consult licensed Veterinarian or Veterinary Services Officer (if available).	malathion (cont) Percent 57.0 EC.	Percent 0.5 E. (1 fl oz/gal water.)	Wet animal thoroughly. Repeat in 2-3 weeks if necessary.
		N/S 4.0 D.	4.0 D.	Make complete coverage. Repeat in 2-3 weeks as necessary. Keep out of eyes.
		carbaryl N/S D.	2.0-5.0 D.	Dust liberally over animal and rub thoroughly into skin. Keep out of eyes.
		80.0 WP.	0.25 Su.	
			1.0 Dip or wash.	For dogs only.
		propoxur N/S A. (Baygon-R.)	0.25 A.	Treat a 5 lb cat for 3-5 seconds. Treat a 15 lb dog for 10-20 seconds. Use proportionate times for various animal sizes. Apply enough to dampen hair and skin.
	Personal protection	diethyltoluamide 75.0 R. (DEET)	75.0 R.	Apply to skin and clothing as required. Keep out of eyes. Damages plastic.
		M-1960 30.0-30.0-30.0 R. (2-butyl-2-ethyl-1,3-propanediol)	30-30-30 R.	To clothing only. Follow label instructions carefully.
Flea: Oriental rat	Residual-Indoors	carbaryl N/S D.	D. 0.1 oz actual/burrow.	Dust in rat runways and harborages. Apply by hand or power applicator.
	Area	carbaryl N/S D.	D. 0.2 oz actual/bait station.	Use 4-6 bait stations per acre.
		D.	D. 1.0 lb actual/Ac.	Apply by hand or power applicator as an area dust treatment.
	Retrograde cargo	dichlorvos 19.2 Strip	19.2 Strip	
Fly: Black, Adult	Outdoor-space	See Mosquito: Adult.		
	Personal protection	diethyltoluamide 55.0 S. (DEET) N/S Rutgers 612 5.0 dimethylphthalate 5.0	R.	Apply to skin and clothing as required. Keep out of eyes. Damages plastics.
		diethyltoluamide 75.0 S.	75.0 R.	
Larva	Larvicide	See Mosquito: Larva.		
Fly: Filter Adult	Residual	No pesticides registered.		
Larva	Filter Bed	Oxford Filtercide-R. 90.0 SC. (mix of malathion, ronnel, chlordane) N/S	S. 1 part SC plus 50 parts water.	Refer to label.
Fly: House & Filth, Adult	Residual-outdoors	naled N/S 50.0 EC.	E. (1.0 lb actual/40 gal water.)	Liberally treat resting surfaces such as walls, beams, and rafters.
		fenthion N/S 93.0 EC.	E. 0.062-0.125 lb actual/gal water/500 sq ft.	Apply as a coarse spray or by paint brush. Apply to interior and exterior surfaces frequented by insects.
		malathion 57.0 EC.	E. (5 TBS EC/1 gal water) spot treat only a rate of 1-2 gal/1,000 sq ft.	Use Grade A for indoor use. Do not apply in edible product areas.
(cont)	(cont)	ronnel N/S	1.0 E. 3 gal/1,000 sq ft.	Apply to agricultural premises.

TABLE A-1 (Cont)

Application of Insecticides

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ST-STAGE	LOCATION-TYPE OF TREATMENT	PESTICIDE/ STOCK STRENGTH/FORM			APPLICATION: STRENGTH, RATE, AND METHOD			REMARKS
			Percent		Percent			
y: House Filth Adult cont)	Residual-Outdoors (cont)	propoxur N/S (Baygon-R.)			1.0	E.	1 gal/500 sq ft.	Apply to point of run off. See fenthion remarks above.
	Bait-dry	No pesticides registered.						
	wet	malathion	57.0	EC.		B.	(5 TBS 57% EC. plus 7 TBS molasses or corn syrup plus 1 gal water.)	Apply as a bait spray over the surface of garbage or manure. May also apply by sprinkler can.
		dichlorvos N/S	42.0	EC.	0.5	B.	(1 fl oz 45% EC plus 3 oz sugar in 3 gal water.)	
		naled N/S	50.0	EC.		B.	1 oz actual/2.5 gal water. (Add 1/2 lb sugar or 1/2 pint corn syrup or molasses/40 gal finished spray.)	
	Space treatment-outdoor	See Mosquito: Adult.						
	Space treatment-indoors	pyrethrins + synergists	3.0	OS.	3.0	OS.		See all sections under indoor space treatment for cockroaches.
		resmethrin			1.2	A.	Apply at a rate of 7 seconds/1,000 cu ft.	ULV treatment can only be used when area is unoccupied. Remove and refrigerate all exposed food. Extinguish all flames. Cover utensils. Shut off all ventilation. Wear goggles and respirator. Minimum exposure time to obtain effective control of pests is 15 minutes. Do not remain in treated room. Ventilate well before reentry. Wash down food preparation surfaces before use.
Larva	Directly to sites for larvae	dimethoate N/S	43.0	EC.	1.25	E.	(1 pt EC in 5 gal water.) 10 gal/1,000 sq ft.	Treat garbage, refuse, manure and other fly breeding areas. Do not contaminate water, feed, or any body of water. Apply as a coarse spray or with a watering can.
		dichlorvos N/S	10.0	EC.	0.5-1.0	E.	(1 qt EC in 16 gal water) 10 gal/1,000 sq ft.	
		malathion	57.0	EC.	0.5	E.	(5 TBS EC/100 sq ft.)	2 qts/100 sq ft.
		paradichlorobenzene	100.0		100.0	crystals	2 oz/garbage can every 1-2 weeks	May apply to pit latrines and slit trenches.
y: Stable Adult	Residual-Outdoors	propoxur	1.0	S.	1.0	S.		Apply to screens, doors, window frames and other surfaces where flies congregate. Do not treat vegetation.
		Ravap-R. N/S	23.0	EC.	1.0-2.0	E.	(1-2 gal EC/25 gal water.) 1 gal/500-1,000 sq ft.	For use as overall application to ceilings and walls of horse stables and around garbage dumps. Use higher rate for extreme infestations.
	Residual-Indoors (cont)	methoxychlor N/S	25.0	EC.	2.5	E.	(1 qt EC or 1 lb WP/2.5 gal water.)	Apply to walls, floors, partitions of stable kennels, or other resting sites. Do not contaminate animal food, drinking water,(cont)
(cont)		(cont)	50.0	WP.	2.5	Su.	1 gal/500 sq ft.	

TABLE A-1 (Cont)

Application of Insecticides

DO NOT SUBSTITUTE THESE RECOMMENDATIONS FOR INFORMATION ON LABELS

PEST-STAGE	LOCATION-TYPE OF TREATMENT	PESTICIDE/ STOCK STRENGTH/FORM			APPLICATION: STRENGTH, RATE, AND METHOD			REMARKS
			Percent		Percent			
Fly: Stable Adult (cont)	Residual-Indoors (cont)	methoxychlor N/S (cont)						(cont) or milk. Exclude dairy animals during treatment
	Space treatment-Outdoors	naled N/S		EC.		E.,OS.	0.05-0.25 lb actual/Ac. Apply 0.5 to 2.0 gal/Ac.	Aerial application. Dilute in water, fuel oil, or odorless kerosene.
			85.0	S.	.	F.	(2 qt S in soybean oil or HAN to make 5 gal.) Apply 3-6 fl oz/minute at 5 mph.	Ground ULV application: refer to product label for specific dilutions and directions for equipment calibration.
Larva	Marine grasses	No pesticide registered.						
	Around garbage and manure	Ravap-R. N/S	23.0	EC.	1.0	E.	(1 gal EC/25 gal water.) 1 gal/100 sq ft of droppings or garbage.	Keep out of lakes, streams or ponds.
Grub:	See white grub							
Hornet:	See Bee							
Louse: Body & Head	Personal Application	malathion	1.0	D.	1.0	D.	Apply by means of hand or power duster to head, cap, sleeve, the back through the neck opening along the seams of clothing thoroughly and to crotch from front to rear.	Consult medical officer or entomologist. Pat clothing to improve distribution. One ounce of dust is sufficient to treat a fully clothed adult. Sprinkle excess dust over bed clothing, blankets and other possible louse habitats. Repeat at 2-3 week intervals as needed.
		lindane	1.0	D.	1.0	D.		
		carbaryl N/S	5.0	D.	5.0	D.		Consult medical officer or entomologist. Dust infested areas. Rub in to insure skin contact. Allow dust to remain in contact with infested areas for at least one hour. Repeat as needed.
Louse: Pubic (crab)	Personal Application	lindane N/S	1.0		1.0	ointment		Issued as a medical item.
		carbaryl N/S	5.0	D.	5.0	D.		See remarks for Louse: Body & Head: Personal Application: carbaryl.
Millipede	Residual-Around Buildings	propoxur (Baygon-R.)	1.0	S.	1.0	S.		Treat interior and exterior perimeter of infested areas or buildings.
		carbaryl	80.0	WP.		Su.	1 lb actual/150 gal water/5,000 sq ft. Apply immediately after rain or watering.	Do not water for at least 2 days after application. Repeat in 2 to 3 weeks if needed.
		lindane	12.0	EC.	0.5	E.	1 gal/1,000 sq ft.	Apply to and near porches, patios, thresholds, ground litter.
		diazinon	47.5	EC.		E.	(8 fl oz EC/3 gal water.) 3 gal/1,000 sq ft.	
			2.0	D.		D.	1-2 lb/1,000 sq ft.	
	Residual-Indoors	propoxur (Baygon-R.)	See Residual-Around Buildings: propoxur.					

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TABLE A-1 (Cont)

Application of Insecticides

DO NOT SUBSTITUTE THESE RECOMMENDATIONS FOR INFORMATION ON LABELS

PEST-STAGE	LOCATION-TYPE OF TREATMENT	PESTICIDE/ STOCK STRENGTH/FORM			APPLICATION: STRENGTH, RATE, AND METHOD			REMARKS
			Percent		Percent			
Mite: Clover	Residual- Indoors or Outdoors	malathion	57.0	EC.	3.0		(2 TBS EC/3 gal water.)	Treat interior and exterior perimeters of infested areas or buildings. Apply as a coarse spray or by paint brush. Pay particular attention to window and door sills, foundations and other areas where clover mites may enter.
		propoxur (Baygon-R.)	1.0	S.	1.0	S.		
	Residual- Outdoors	diazinon	47.5	EC.		E.	(4 fl oz EC/3 gal water.) 3 gal/1,000 sq ft.	To prevent entry into buildings spray a 5 ft band of soil around the structure as well as the foundation wall to a height of 2-3 feet. Repeat as necessary. Do not contaminate any body of water. Toxic to fish and wildlife.
		dicofol N/S (Kelthane-R.)		EC.		E.	0.3-0.4 lb actual/100 gal water. Apply 2.5 gal/1,000 sq ft.	To control mite populations and prevent their migration to adjoining buildings. Treat base of buildings as well as window sills and other possible entrances. Apply to lawns, shrubs and trees near buildings. Repeat in 10 to 14 days if needed.
		N/S		WP.		Su.	0.28-0.47 lb actual/100 gal water. Apply 2.5 gal/1,000 sq ft.	
		chlorobenzilate N/S		EC., WP.		E., Su.	0.25-0.37 lb actual/100 gal water. Apply as a drenching spray to lawns and shrubs.	Above remarks for Kelthane apply except apply chlorobenzilate to lawns within 15 feet of buildings. Repeat in 7-10 days if needed.
Mite: Chigger "Red Bug"	Outdoor-Area	diazinon	47.5	EC.		E.	(1¼ fl oz EC/3 gal water. 3 gal/1,000 sq ft.	Apply thoroughly to lawns. Do not contaminate food crops. Avoid drift. Keep children and pets away until dry. Treat lawns, tall grasses and weeds, ornamental plants, brush, logs and tree trunks.
		lindane	12.0	EC.	1.0	E.	0.25-0.5 lb actual/Ac.	
	Personal Protection	diethyltoluamide (DEET)	75.0	R.	75.0	R.		Apply to skin or clothing as required. Repeated applications may result in blisters at bend of the knees and elbows.
		M-1960 (2-butyl-2-ethyl-1,3-propanedial)	30.0-30.0-30.0	R.	30-30-30	R.		To clothing only. Follow label instructions carefully.
Mite: Spider	Outdoor- Residual on ornamental plants	chlorpyrifos (Dursban-R.)	40.8	EC.		E.	(0.25 lb actual/100 gal water.)	Foliage application. Apply as a coarse spray. Do not use on poinsettias. Keep out of any body of water. Toxic to fish and wildlife. Keep children and pets from treated areas until spray is dry.
		dimethoate N/S	23.4	EC.		E.	(2 tsp/gal water.)	Foliage application only for specific ornamentals; refer to label. Do not use in greenhouses
		malathion	57.0	EC.		E.	(2 tsp/gal water.)	Cover plants thoroughly. Avoid drift. Check label for plant species that might sustain injury.
		nicotine sulfate	40.0	S.		S.	(3.0 tsp S./gal water.)	Foliage application. Add 0.5 pint molasses.
	Residual- dormant spray	superior-type oil			Follow directions on label.			Follow directions on label since some plants may be injured.

TABLE A-1 (Cont)

Application of Insecticides

DO NOT SUBSTITUTE THESE RECOMMENDATIONS FOR INFORMATION ON LABELS

PEST-STAGE	LOCATION-TYPE OF TREATMENT	PESTICIDE/ STOCK STRENGTH/FORM			APPLICATION: STRENGTH, RATE, AND METHOD			REMARKS
			Percent		Percent			
Mite: Scabies	Personal	BHC (lindane)	1.0		1.0		gamma ointment	Apply to infected skin after consulting physician.
Mite: Bird, Mouse & Tropical rat	Indoor or on Outdoor walls	malathion	57.0	EC.		E.	(2 tsp EC/gal water.)	Remove bird and rodent nests and spray area.
	In or on roost areas	Rabon-R. N/S	3.0	D.	3.0	D.	One lb dust/100 sq ft.	For control of northern fowl mites and chicken mites. Treat roost areas thoroughly, particularly cracks and crevices.
		N/S	50.0	WP.	1.0	Su.	(5 TBS WP/gal water.) 1 pint/100 sq ft.	
		N/S	24.0	EC.	1.0	E.	(6 fl oz EC/gal water.) 1 pint/100 sq ft.	
	Indoor-space spray	pyrethrin, synergized	0.5	A.	0.5	A.	7 seconds/1,000 cu ft with aerosol dispenser	
	Personal protection	Same as for ticks.						
Mole: Cricket	See Cricket:	Mole						
Mosquito: Adult	Outdoor-space treatment	chlorpyrifos (Dursban-R.)		EC.			0.025-0.05 lb actual/Ac (in water or oil)	Use low dosage in light to medium vegetative cover. Use high dosage in medium cover or for faster knockdown and longer residual control in open areas and those with light to medium vegetative cover. Do not allow to get into any body of water.
		naled	85.0	S.		[illegible]	0.01-0.02 lb actual/Ac.	Ground ULV application by non-thermal or thermal fog generator. Refer to product label for specific directions for dilutions and equipment calibration. Do not apply over shrimp producing areas.
			85.0	S.	85.0	S.	0.05-0.11 lb actual/Ac.	Aerial ULV application. Apply undiluted. Use higher dosage where heavy vegetation exists.
		dichlorvos N/S	22.8	EC.	1.0	F.	in oil	Apply by fogging machines. Highly toxic to fish - avoid lakes, streams and ponds.
		pyrethrins + piperonyl butoxide			5.0		pyrethrins + 25% piperonyl butoxide in oil ULV. Use 0.002-0.0025 lbs actual/Ac. Flow rate 2.0-2.25 oz/min at 5 mph.	Use Klearol-R. as a diluent.
		resmethrin N/S	50.0				(12.5 fl oz/gal light mineral oil 74 viscosity.) Apply at rate of 3 fl oz/Ac(0.007 lbs actual/Ac.)	ULV. Keep out of lakes, streams or ponds. Apply by truck mounted equipment.
		malathion	57.0	EC.	6.0	E., OS., F.		May be ineffective due to resistance.
			95.0	S.	95.0	ULV		Ground application: Use undiluted at 4.3 oz per minute at 10 mph vehicle speed. Mass median diameter of droplets should not exceed 17 microns. Aerial application: Apply at rate of 3 fl oz/acre. Toxic to fish. Damages auto paint.
(cont)	(cont)							

TABLE A-1 (Cont)

Application of Insecticides

DO NOT SUBSTITUTE THESE RECOMMENDATIONS FOR INFORMATION ON LABELS

PEST-STAGE	LOCATION-TYPE OF TREATMENT	PESTICIDE/ STOCK STRENGTH/FORM			APPLICATION: STRENGTH, RATE, AND METHOD			REMARKS
			Percent		Percent			
Mosquito: Adult (cont)	Outdoor space treatment (cont)	fenthion N/S	93.0	S.	93.0	ULV		For ground application in Texas and Florida only. For use only by personnel experienced and knowledgeable with regard to correct calibration and use of proper ULV nonthermal equipment. Consult label.
	Outdoor residual	malathion	57.0	EC.		E., OS.	(1 part to 28 parts water, diesel oil, or fuel oil.)	Spray building foundations, shrubs, low trees and lawn areas. Keep children and pets from treated areas until spray dries. May burn vegetation.
		chlorpyrifos (Dursban-R.)	40.8	EC.		E.	0.025-0.05 lb actual/Ac.	Amount per acre dependent on vegetation: Low dosage in light and medium vegetation cover. High dosage in medium to heavy. Toxic to some aquatic and bird life.
		propoxur (Baygon-R.)	1.0	S.	1.0	S.		Apply to screens, doors, window frames, foundations and surfaces where mosquitoes congregate.
		N/S	75.0	EC.		E.	(3/4 cup/gal water.)	
		N/S		EC.		E.	0.05-0.07 lb actual/Ac.	Mist application. Do not allow to drift or use on crop land or pasture lands. Adjust equipment to deliver 100 gallons per hour at 4 mph to cover up to a 350 foot swath.
		carbaryl		WP., D.		Su., D.	0.25-0.5 lb actual/Ac.	Mist or dust application. Thorough coverage is necessary for effective control. For optimum control, apply in early morning or evening when air is calm and adults are active. May kill shrimps and crabs.
	Indoor space treatment	resmethrin	1.2	A.	1.2	A.	Apply at 7 seconds/1,000 cu ft.	Remove or refrigerate all exposed food. Cover utensils.
		pyrethrins, synergized	0.5	A.	0.5	A.		
	Indoor residual	malathion	57.0	EC.		E.	(5 TBS EC/gal water.) 1 gal/1,000 cu ft.	Apply to walls and ceilings. Do not contaminate food. Keep children and pets away until spray dries.
	Personal protection	diethyltoluamide (DEET)	75.0	R.	75.0	R.		Apply liberally to exposed skin and where clothing fits tightly. Avoid eyes and mucous membranes. Also avoid folds of skin in bend and behind knees.
Mosquito: Larva (cont)	Larvicide (cont)	Abate-R. N/S		G.		G.	0.05-0.5 lb actual/Ac.	Dosage dependent upon habitat - consult label. Young shrimp in treated tidal waters will be killed at these application rates.
		N/S		EC.		EC.	0.25-0.75 oz actual/Ac.	
		fenthion N/S		EC.		E., OS.	0.05 lb actual/Ac.	May be toxic to fish and wildlife. Do not apply to ponds, lakes, streams, or other bodies of water containing fish. Apply as a light uniform spray. Broadcast granules uniformly over moist areas, standing pools, marshes, swamps, tidal areas and other mosquito breeding sites.
		N/S		G.		G.	0.05-0.2 lb actual/Ac.	

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TABLE A-1 (Cont)

Application of Insecticides

DO NOT SUBSTITUTE THESE RECOMMENDATIONS FOR INFORMATION ON LABELS

PEST-STAGE	LOCATION-TYPE OF TREATMENT	PESTICIDE/ STOCK STRENGTH/FORM			APPLICATION: STRENGTH, RATE, AND METHOD			REMARKS
			Percent		Percent			
Mosquito: Larva (cont)	Larvicide (cont)	malathion	57.0	EC.	E., OS.		13 fl oz EC/Ac. Mix in sufficient oil when applied by air or ground equipment.	See label for habitat-dependent rates. Apply as a light, uniform spray. Broadcast granules uniformly over moist areas, standing pools, marshes, swamps, tidal areas and other mosquito breeding sites. Toxic to some aquatic and bird life.
		chlorpyrifos (Dursban-R.)	41.2	EC.		E.	0.0125-0.05 lb actual/Ac.	
			1.0	G.	1.0	G.	2.5-5.0 lbs/Ac. over flooded areas. 10 lb/Ac. for pre-hatch treatment.	
		paris green N/S		G.		G.	0.5-1.0 lb actual/Ac.	For Aedes, Psorophora and Anopheles spp as broadcast application under general flood water conditions. Must be applied before 4th Instar. Repeat as needed.
		Flit MLO-R.	100.0	OS.	100.0	OS.		Ground Application: 2-3 gal/acre for zero to medium vegetative cover and/or surface debris. 3-5 gal/acre, medium to heavy cover and/or debris. 5 gal/acre in sewage ponds. Aerial Application: 1-2 gal/acre for medium vegetative cover and/or surface debris. 2-3 gal/acre, medium to heavy cover and/or debris
Pillbug	Residual-Outdoors	chlorpyrifos (Dursban-R.)	40.8	EC.		E.	0.115-0.117 lb actual/ 5,000 sq ft.	Lawn and turf should be moist at time of application. Apply as a coarse, low pressure spray in 150 gallons of water. Keep out of any body of water. Keep children and pets off treated area until spray has completely dried.
Reduviid: (Conenose,	Assassin, or Kissing bug)	No pesticide registered at present time.						
Scale Insects	Residual-Outdoors on ornamentals	malathion	57.0	EC.		E.	(2-6 tsp EC/gal water.)	Check label for specific scale species and rates. Foliage application: Apply as coarse spray when scale "crawlers" have settled on foliage. Keep children and pets away from treated areas until spray dries.
		dimethoate N/S	23.4	EC.		E.	(2 tsp EC/gal water.)	
		mineral oil and emulsifier					2.5 fl oz/gal water as needed.	Primarily for treatment of infested trees before spring budding.
Scorpion	Residual-Indoors	diazinon N/S	48.7	S.	0.5	OS.		Thoroughly spray or brush or dust around door and window sills, baseboards, closets, storage cabinets, openings around water pipes, wall cracks or wherever these pests may enter, congregate, feed or hide in the home. Use in edible product areas only as crack and crevice treatment. Avoid until dry.
			47.5	EC.	0.5	E.	(2½ TBS EC/gal water.)	
			2.0	D.	2.0	D.		
(cont)	(cont)							

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TABLE A-1 (Cont)

Application of Insecticides

DO NOT SUBSTITUTE THESE RECOMMENDATIONS FOR INFORMATION ON LABELS

PEST-STAGE	LOCATION-TYPE OF TREATMENT	PESTICIDE/ STOCK STRENGTH/FORM			APPLICATION: STRENGTH, RATE, AND METHOD			REMARKS
			Percent		Percent			
Scorpion (cont)	Residual-Indoors (cont)	propoxur (Baygon-R.)	1.0	S.	1.0	S.		Treat interior perimeter of infested areas.
	Residual-Outdoors	propoxur (Baygon-R.)	1.0	S.	1.0	S.		Treat exterior perimeters of infested areas or buildings.
		diazinon	2.0	D.	2.0	D.		Make spot applications to surfaces over which these pests crawl, particularly in crawl spaces under houses or buildings.
			47.5	EC.	0.5	E.	(2½ TBS EC/gal water.)	
Silverfish	Residual-Indoors	diazinon	2.0	D.	2.0	D.		Dust all areas around waterpipes, in cracks, under and behind cabinets and bookcases.
			47.5	EC.	0.5	E.	(1½ TBS EC/gal water.)	Apply as a coarse spray or apply with a paint brush to baseboards, areas around water pipes, cracks and crevices, surfaces behind and beneath cabinets, refrigerators, sinks, stoves, and similar areas where insects hide. Do not allow pets or children to contact treated surfaces.
		malathion	57.0	EC.		E.	(1 pt/2½ gal water.)	
		propoxur (Baygon-R.)	1.0	S.	1.0	S.		Treat areas where pests hide or tend to congregate. Apply as a spray or with a paint brush. Cracks and crevices may be treated using an oil can.
Snails & Slugs	Residual	metaldehyde N/S	10.0	G.	10.0	G.	Apply in accordance with label.	See also: Technical Information Memoranda Nos. 1 & 5, The Armed Forces Pest Control Board. Apply to soil around plants. Do not use around food crops. Use around flower beds, greenhouses and building foundations. Lightly water area to be treated before applying bait.
		Mesurol-R. N/S	2.0	B.	2.0	B.	0.32 oz actual/1,000 sq ft.	
Sod webworm	Area-residual on turf and lawn	chlorpyrifos (Dursban-R.)	40.8	EC.		E.	(0.75 fl oz EC/30 gal water.) 0.1-0.117 lb actual/5,000 sq ft.	Thoroughly wet down grass a few hours before applying. Do not permit children or pets to go on to sprayed grass until spray has completely dried. Keep out of lakes, streams and ponds.
		diazinon	47.5	EC.		E.	(4 fl oz EC/3 gal water/ 1,000 sq ft.)	
Sowbug	Residual-Outdoors	propoxur (Baygon-R.)	1.0	S.	1.0	S.		Treat interior and exterior perimeter of infested areas or buildings.
		diazinon	47.5	EC.		E.	Apply 4 fl oz EC/3 gal water/1,000 sq ft.	Spray a 5 foot band of soil around building as well as the building foundation to a height of 2-3 feet. Keep out of any body of water. Do not permit children or pets to go onto sprayed area until dry.
		chlorpyrifos (Dursban-R.)			See Pillbug			

TABLE A-1 (Cont)

Application of Insecticides

DO NOT SUBSTITUTE THESE RECOMMENDATIONS FOR INFORMATION ON LABELS

PEST-STAGE	LOCATION-TYPE OF TREATMENT	PESTICIDE/ STOCK STRENGTH/FORM	APPLICATION: STRENGTH, RATE, AND METHOD	REMARKS
		Percent	Percent	
Spider	Residual-Indoors	propoxur (Baygon-R.) 1.0 S.	1.0 S.	Propoxur may be applied to interior and exterior perimeters of infested areas of buildings. Spot treat with propoxur and others where spiders tend to spin webs: around windows, doors and along baseboards. May use diazinon as a coarse spray or with paint brush. Diazinon dust is valuable in crawl spaces. Do not use as space spray. Keep children and pets off until dry.
		chlorpyrifos (Dursban-R.) 40.8 EC.	0.25-0.5 E.	
		diazinon 47.5 EC.	0.5 E. (2½ TBS EC/gal water.)	
		2.0 D.	2.0 D.	
	Fumigant	No pesticide registered.		
Springtail	Residual-Outdoors on lawns	diazinon 47.5 EC.	(4 fl oz EC/3 gal water.) 3 gal/1,000 sq ft.	To prevent entry into buildings spray a 5 ft band of soil around the structure, as well as the foundation wall to a height of 2-3 feet.
Stored Product Pests	Residual-Indoors	malathion 57.0 EC.	4.0 E.	For exposed stages of saw toothed grain beetle, flour beetle, rice weevil, cigarette beetle, drugstore beetle, Indian meal moth. Apply to shelves and cupboards (after removing food containers and shelving paper) Do not replace the food packages and paper until spray has dried.
		diazinon 47.5 EC.	0.5 E. (2½ TBS EC/gal water.)	
	Fumigation	aluminum phosphide 55.0 P.		To be used only by fumigators specially trained in aluminum phosphide fumigation. Do not use methyl bromide to fumigate soya flour.
		methyl bromide + chloropicrin 100.0 Fm.		
	Indoor space treatment	pyrethrins + synergists	3.0 OS. + synergists ULV application	Close all ventilation. Do not contaminate food. Apply only when facility is not in operation. Wear respirator and goggles. Ventilate prior to reentry.
		dichlorvos 19.2 G.	Vapor	Used with dispensing apparatus. Comply with label.
Tent Caterpillar & Fall Web-worm	Residual on ornamentals-Outdoors	diazinon 47.5 EC.	E. (1½ fl oz EC/3 gal water)	Apply as a thorough foliage spray when adults first appear. Make a second and third application at 4-5 week intervals. Keep out of any body of water. Carbaryl injures Boston Ivy and Virginia creeper.
		carbaryl 80.0 WP.	Su. (1 lb actual/100 gal water)	
		malathion 57.0 EC.	E. (2 tsp EC/gal water)	
		N/S 25.0 WP.	Su. (2 TBS WP/gal water)	
	Pathogen for use on trees and shrubs	Bacillus N/S thuringiensis WP.	Su. 0.25-0.375 billion international units/3 gal water on small plots. 2.0-8.3 BIU/100 gal water on larger plots or /Ac.	Foliage application. Use restricted to Western United States for Great Basin caterpillar.
			WP. 1.8-3.6 BIU/Ac.	

TABLE A-1 (Cont)

Application of Insecticides
DO NOT SUBSTITUTE THESE RECOMMENDATIONS FOR INFORMATION ON LABELS

PEST-STAGE	LOCATION-TYPE OF TREATMENT	PESTICIDE/ STOCK STRENGTH/FORM			APPLICATION: STRENGTH, RATE, AND METHOD			REMARKS
			Percent		Percent			
Termite: dampwood	All; see "Application" column	chlordane	72.0	EC.	1.0	E.	Same as for subterranean termites for soil-inhabiting colonies.	Same as for drywood termites for above-ground colonies.
		dieldrin	15.0	EC.	0.3	E.		
Termite: drywood	Residual	paris green N/S	100.0	SP.	100.0	SP.		Force dust into galleries through drilled holes 3/16-1/4 inch diameter at 12-18 inch intervals.
		pentachlorophenol			5.0	OS.	See para 7.7.5.4(1).	Apply to surface or drill and inject.
	Fumigation	sulfuryl fluoride N/S	99.0	Fm.		Fm.	Dosage is calculated based on temperature, exposure, and fumigant concentration loss rate.	Use Fumiguide B. calculator. To be used by certified fumigators only.
		methyl bromide (containing 2% chloropicrin)	98.0	Fm.		Fm.	Apply 2½-3 lbs/1000 cu ft at temperatures above 70°F Under adverse conditions use 3½-3 3/4 lbs/1000 cu ft	Some materials may be damaged by methyl bromide; check label for list of these mate-erials. To be used by certified applicators only.
Termite: Formosan		No pesticide products are registered for controlling this termite by name. Use products labeled to control subterranean termites.						
Termite: Subterranean	Pre-Slab	chlordane	72.0	EC.	1.0	E.	1.5 gal/10 sq ft of surface before slab is poured. 4 gal/10 linear ft of trench along perimeter and under expansion joints for each 1 ft of depth.	Treat after compaction of fill but before placement of granular fill used as capillary water barrier.
		dieldrin	15.0	EC.	0.3	E.		
	Sub-Slab (injection)	chlordane	72.0	EC.	1.0	E.	3 gal/hole. Inject at 150 lbs/sq in.	Holes drilled at 12-18 inch intervals 6-8 inches from cracks and expansion joints.
		dieldrin	15.0	EC.	0.3	E.		
	Voids of piers, masonry walls	chlordane	72.0	EC.	1.0	E.	Flood voids at rate of 2 gal/10 linear feet	
		dieldrin	15.0	EC.	0.3	E.		
	Foundation and basement walls and grade beams	chlordane	72.0	EC.	1.0	E.	4 gal/10 lin ft/each ft of depth in trench 1 ft wide. Apply 1/3 at bottom, 1/3 when back-fill half completed, and 1/3 near top.	Mix well with back-fill. Additional ½ gal per sq ft 6 in. around utility openings. Trench to 3 ft below grade or to top of footing or base of grade beam, whichever is lesser depth.
		dieldrin	15.0	EC.	0.3	E.		
	Foundations of buildings with crawl space	chlordane	72.0	EC.	1.0	E.	as per above. Treat out to one ft on all sides of materials which contact the ground.	Examples of materials which contact ground are: walls, grade beams, piers, interior support walls, metal ducts, plumbing, and electrical conduits.
		dieldrin	15.0	EC.	0.3	E.		
Thrips	Residual on ornamentals	diazinon	47.5	EC.		E.	(1/2 fl oz EC/3 gal water)	Apply as coarse spray to point of runoff. Foliage applications: check label for plant species that may sustain injury by these chemicals. These products are toxic to fish and wildlife. Keep out of any body of water. Do not apply where runoff is likely to occur. Do not allow children and pets to contact treated vegetation until dry.
		malathion	57.0	EC.		E.	(2 tsp EC/gal water)	
		chlorpyrifos (Dursban-R.)	40.0	EC.		E.	(0.5 lbs actual/100 gal water)	
		dimethoate N/S	23.4	EC.		E.	(2 tsp EC/gal water)	

TABLE A-1 (Cont)

Application of Insecticides

DO NOT SUBSTITUTE THESE RECOMMENDATIONS FOR INFORMATION ON LABELS

PEST-STAGE	LOCATION-TYPE OF TREATMENT	PESTICIDE/ STOCK STRENGTH/FORM			APPLICATION: STRENGTH, RATE, AND METHOD			REMARKS
			Percent		Percent			
Tick: General	Outdoor area control	diazinon	47.8	EC.		E.	(1¼ fl oz EC/3 gal water) Apply above mixture to 1,000 sq ft.	Spray a five-foot band around building as well as foundation wall to a height of 2-3 ft. Repeat application if necessary. For brown dog tick spray grass and under shrubbery, particularly near house. Do not apply to animals.
		chlorpyrifos (Dursban-R.)	40.8	EC.		E.	0.25 lb actual/40-100 gal water/Ac.	Apply where ticks are a nuisance or are a possible public health problem. Treat grassy areas, low underbrush, weeds, ground surface and debris.
		Rabon-R. N/S		EC. WP.	0.5	E. Su.	1 lb actual/Ac.	Thoroughly spray infested areas using approximately 25 gallons of spray per acre. Also treat grassy and bushy areas near recreation sites and along foot paths and roadsides leading to them.
		carbaryl	80.0	D.	80.0	D.	0.125-0.25 lb actual/ 5,000 sq ft.	Apply liberally to ground, debris, and vegetation to a height of about 2 feet on lawns, vacant fields and wooded areas around the frame. Repeat as needed.
	Animal treatment Consult licensed Veterinarian or Veterinary Services Officer (if available).	carbaryl N/S	2.0-5.0	D.	2.0-5.0	D.		Dust liberally over animal and rub thoroughly into skin. For brown dog tick be sure also to apply on legs, feet and between toes. Keep dust out of eyes.
		carbaryl N/S			0.25 5.0	OS. dip and wash.		Ruffle coat of long-haired animals first and spray against lay of the hair. Spray ticks directly. Do not treat puppies less than 4 weeks old. Do not get in eyes.
		malathion	57.0	EC.		E.	(1 fl oz EC/gal water.)	Wet animal thoroughly. Repeat in 2-3 weeks as necessary.
		N/S	5.0	A.	5.0	A.		Apply 25-30 seconds per 18-20 lb dog. Spray from neck to tail, legs, and under body. Keep out of eyes. Repeat in 7 days. Wash hands after application.
	Personal Protection	diethyltoluamide (DEET)	75.0	R.	75.0	R.		Apply liberally to exposed skin and where clothing fits tightly. Avoid eyes and mucous membranes. Repeated applications to folds of skin at elbows and knees may cause blisters. Damages plastic.
		M-1960 (2-butyl-2-ethyl-1,3-propanediol)	30.0-30.0-30.0	R.		R.		Clothing repellent only. Follow label instructions.
Tick: Brown dog (cont)	Residual-Indoors (cont)	chlorpyrifos N/S (Dursban-R.) (cont)			0.5	E. or OS.		Spot treat only. Apply as a coarse spray or with a paint brush to infested areas such as pet beds and resting areas, nearby cracks and crevices, along and behind baseboards, window and door frames and (cont)

TABLE A-1 (Cont)

Application of Insecticides

DO NOT SUBSTITUTE THESE RECOMMENDATIONS FOR INFORMATION ON LABELS

PEST-STAGE	LOCATION-TYPE OF TREATMENT	PESTICIDE/ STOCK STRENGTH/FORM			APPLICATION: STRENGTH, RATE, AND METHOD			REMARKS
			Percent		Percent			
Tick: Brown dog (cont)	Residual-Indoors (cont)	chlorpyrifos N/S (cont)			0.5	E. or OS.		(cont) other localized areas. Replace old bedding after treatment. Do not treat animals. Do not allow children and pets to contact treated surfaces until spray dries.
		propoxur (Baygon-R.)	1.0	S.	1.0	S.		Treat infested areas particularly cracks, crevices, and along baseboards. Apply as a spray or with a paint brush. Do not treat animals.
		carbaryl	80.0	WP.	0.8	Su.		Use restricted to certified pest control operators only. Apply as a coarse wet spray or with a paint brush. Thoroughly treat cracks, crevices, baseboards, corners, walls, door frames, window sills, sleeping quarters of household pets, outside perimeter of dwellings and other areas where ticks tend to congregate. Repeat as needed up to twice a week. Do not treat animals.
		diazinon	47.5	EC.	0.5	E.	(1¼ fl oz/gal water)	
	Residual-Outdoors	diazinon: See Tick: General - Outdoor area control.						
		chlorpyrifos (Dursban-R.)	40.8	EC.		E.	0.115-0.117 lbs actual/ 5,000 sq ft.	Apply as a coarse, low pressure spray to grass in 150 gallons of water. Lawn and turf should be moist at time of application. Do not mow for 24 hours following treatment.
		carbaryl: See Tick: Brown dog : Residual-Indoors: carbaryl.						
Wasp:	See: Bee							
Whitefly	Outdoors-Residual on ornamentals	diazinon	47.5	EC.		E.	(1/2 fl oz EC/3 gal water.)	Apply as coarse spray. Keep out of any body of water. Toxic to fish and wildlife. Check labels to determine which plant species may sustain injury from these respective chemicals. Do not allow human contact until spray dries.
		chlorpyrifos (Dursban-R.)	40.8	EC.		E.	(1/4 lb actual/100 gal water.)	
		malathion	57.0	EC.		E.	(2 tsp EC/gal water.)	
Whitegrub	Outdoors-Residual on golf courses, park, ornamental turf and cemeteries.	diazinon N/S	14.3	G.	14.3	G.	1 lb G/1,000 sq ft.	Water grass thoroughly after application. Apply any time between late July and early October.
		N/S	5.0	G.	5.0	G.	2½ lb G/1,000 sq ft.	
		trichlorfon N/S (Dylox L.S.-R.)	40.5	EC.		E.	(3/8 pints EC/15 to 30 gal water.) Apply 15 to 30 gal finished mixture to 1,000 sq ft.	Apply by watering can, hose-end sprayer, compressed air or commercial power sprayer. Water grass and allow to dry before spraying. Do not water again for three weeks. Toxic to birds and wildlife. Do not allow children and pets on area until spray dries
Yellow Jacket	See: Bee							

TABLE A-2

Application of Rodenticides

DO NOT SUBSTITUTE THESE RECOMMENDATIONS FOR INFORMATION ON LABELS

-STAGE	LOCATION-TYPE OF TREATMENT	PESTICIDE/ STOCK STRENGTH/FORM	APPLICATION: STRENGTH, RATE, AND METHOD	REMARKS
		Percent	Percent	
er: ket, ntain, ins	Bait	Gophacide-R. N/S 0.2 B.	0.2 B. 1½ lbs per acre in burrows spaced at 20 foot intervals.	Place in artificial burrows. Treatment of natural burrows may be made at rate of 1½ lbs per acre of area to be treated. For use only by personnel experienced in pocket gopher control.
nd irrel	Bait	No materials registered.		
	Bait	strychnine N/S 0.3-0.85 B.	0.3-0.85 B.	On lawns: roll turf or press down sections of raised runways with heel and mark these sites. Probe into active runways which will be raised back in 24 hours. Probe with a sharp stick at 10-foot intervals and drop several particles of bait into the probe hole. Cover hole so as to exclude light and loose dirt.
e: vest, dow, e, te- footed	Bait	zinc phosphide 74.7 P.	1.0-2.0 B. (Mix one oz of toxicant with 4½ oz of bait materials such as rolled oats mixed with bacon grease or corn oil.)	Place baits next to runways or burrows. In buildings put out bait in protected boxes, secured from children, pets and domestic animals.
e: se	Dry bait, anticoagulant	Ready mixed bait	According to directions on label.	Place tablespoon amounts of bait at 8 to 12 foot intervals where mice feed, water or travel along walls in corners and in concealed places. An uninterrupted supply of bait should be maintained for at least 15 days or until all signs of rodent activity have stopped. If these bait sites are accessible to children, pets or domestic animals, they should be kept in tamper proof boxes. Replace contaminated or exhausted bait within 24 hours. Where a continuous source of infestation is present, permanent bait stations should be established and bait replenished as needed. Baits should be picked up and disposed of upon completion of control program.
		Universal concentrate containing diphacinone, fumarin, pival, or PMP.		
		diphacinone N/S 0.1	0.005 B. (Mix one part of weight of the concentrate to 19 parts of bait materials (ground corn, oats or other grain.)	
		fumarin N/S 0.5	0.025 B.	
		pival N/S 0.5	0.025 B.	
		warfarin N/S 0.5	0.025 B.	
		PMP N/S 1.1	0.055 B.	
ont) .	Dry bait, other (cont)	zinc phosphide 74.7 P. (cont)	1.0-2.0 B. (Mix toxicant with fresh bait materials (corn meal, fish, meat, fruit, etc.) at rate of one oz of toxicant to 4½ lbs of bait material	Do not use foods which will be attractive to children, such as candy, cookies, nuts etc. BUILDINGS: Place tablespoon amounts of bait at 8 to 10 foot intervals where mice are active. Expose along walls, corners and concealed places. Bait placements (cont)

TABLE A-2 (Cont)

Application of Rodenticides

DO NOT SUBSTITUTE THESE RECOMMENDATIONS FOR INFORMATION ON LABELS

PEST-STAGE	LOCATION-TYPE OF TREATMENT	PESTICIDE/ STOCK STRENGTH/FORM	APPLICATION: STRENGTH, RATE, AND METHOD	REMARKS
Mouse: House (cont)	Dry bait, other (cont)	Percent	Percent	(cont) should be inaccessible to children, pets or domestic animals or exposed in tamperproof boxes. Collect and destroy uneaten baits at the end of 72 hours. Do not retreat with zinc phosphide for 30 days.
	Liquid bait, anticoagulant	Universal concentrate containing diphacinone, fumarin, pival, or PMP.	According to label directions.	Expose liquid bait in glass or plastic chick watering devices. Place containers where mice feed, water or travel along walls, in corners and concealed places. An uninterrupted supply of bait should be maintained for at least 15 days or until signs of mouse activity have stopped. If these bait sites are accessible to children, pets or domestic animals, they should be kept in tamperproof boxes. When water is exhausted, becomes cloudy or otherwise contaminated, replace with fresh solution within 24 hours. Remove all other sources of water insofar as possible. Where a continued source of infestation is present, permanent bait stations should be established and the bait replenished as needed. Supplement with cereal type anticoagulant baits. Dead mice should be picked up and baits disposed of in a safe manner upon conclusion of the baiting program. Pick up or burn all carcasses of pests killed.
		diphacinone N/S 0.106* S.	0.0015 B. (Dissolve the prescribed amount of concentrate in prescribed amount of water.)	
		fumarin N/S 1.20 C.	0.14 B.	
		pival N/S 0.30 C.	0.0275 B.	
		warfarin N/S 0.127 to 0.14 C.	0.01 B.	
		PMP N/S 1.1	0.055 B.	
	Tracking powder	chlorophacinone N/S 0.2 D.	0.2 D. 1 lb/40 sq ft of runway area.	For use only in areas where there is no possibility of food contamination or contamination of surfaces that come in direct contact with food. Place in mouse runways or avenues of travel. Dust tracking powder into holes, burrows, runways through which mice travel from nests to feeding places. Repeat treatment as necessary. Place in locations inaccessible to children, pets, wildlife, and domestic animals, or in tamper proof bait boxes.
Prairie dog	Bait	strychnine N/S 0.3-0.5 B.	0.3-0.5 B.	Prebait with unpoisoned grain for 3 days. Scatter tablespoon quantities of bait at edge of bare ground around the mound on the side away from the pile of dirt removed from burrow. Consult Fish and Game authorities for presence of endangered black-footed ferret before controlling a specific town.

TABLE 2 (Cont)

Application of Rodenticides

DO NOT SUBSTITUTE THESE RECOMMENDATIONS FOR INFORMATION ON LABELS

PEST-STAGE	LOCATION-TYPE OF TREATMENT	PESTICIDE/ STOCK STRENGTH/FORM	APPLICATION: STRENGTH, RATE, AND METHOD	REMARKS
Rat: Norway & Roof	Dry bait	Percent Ready mixed baits	Percent Apply according to directions on label.	Apply 4 to 16 ounces of bait per placement. Put baits in locations where rats feed, water or travel along walls, in corners and in concealed places. An uninterrupted supply of bait should be maintained for at least 10 days or until all signs of rodent activity have stopped. If these bait sites are accessible to children, pets or domestic animals, they should be kept in tamperproof boxes. Replace contaminated or exhausted bait within 24 hours. Where a continuous source of infestation is present, permanent bait stations should be established and the bait replenished as needed. Dead rats should be picked up and baits disposed of in a safe manner upon conclusion of the baiting program. Each of these respective dry bait percentages may be used in cereal baits which are impregnated in paraffin. The paraffin bait blocks may be used in sewers and other damp outdoor locations. These paraffin bait blocks should not be used to replace other baits in dry locations.
		Universal concentrate containing diphacinone, fumarin, pival, or PMP.		
		diphacinone N/S 0.1	0.005 B. (Mix one part by weight to 19 parts of bait materials (ground corn, oats, or other grain).)	
		fumarin N/S 0.5	0.025 B.	
		pival N/S 0.5	0.025 B.	
		warfarin N/S 0.5	0.025 B.	
		PMP N/S 1.1	0.05 B.	
		zinc phosphide 74.4	1.0-2.0 B. (Mix one oz toxicant with 4½ lb bait materials such as diced fresh coconut, fish, ground meat.)	Do not use foods which will be attractive to children, such as candy, cookies, nuts etc. BUILDINGS: Place tablespoon amounts of bait at 8 to 10 foot intervals where rats are active. Expose along walls, corners and concealed places. Bait placements should be inaccessible to children, pets or domestic animals or exposed in tamperproof boxes. Collect and destroy uneaten baits at the end of 72 hours. Do not re-treat with zinc phosphide for 30 days.
		diphacin bait block	One block per container	For retrograde cargo only.
	Liquid bait	Universal concentrate containing diphacinone, fumarin, pival or PMP.	According to label directions.	Expose liquid bait in glass or plastic chick watering devices. Place containers where rats feed, water or travel along walls, in corners and in concealed places. An uninterrupted supply of bait should be maintained for at least 10 days or until all signs of rodent activity have stopped. If these bait sites are accessible to children, pets or (cont)
		diphacinone N/S 0.106 S.	0.0015 B. (Dissolve the prescribed amount of concentrate in prescribed amount of water.)	
		fumarin N/S 0.5 C.	0.14 B.	
		pival N/S 1.5 C.	0.3 B.	
		warfarin N/S 0.54 S.	0.01 B.	
		PMP N/S 1.1	0.055 B.	
(cont)	(cont)			

TABLE A-2 (Cont)

Application of Rodenticides

DO NOT SUBSTITUTE THESE RECOMMENDATIONS FOR INFORMATION ON LABELS

PEST-STAGE	LOCATION-TYPE OF TREATMENT	PESTICIDE/ STOCK STRENGTH/FORM	APPLICATION: STRENGTH, RATE, AND METHOD	REMARKS
		Percent	Percent	
Rat: Norway & Roof (cont)	Liquid bait (cont)			(cont) domestic animals, they should be kept in tamperproof boxes. When water is exhausted, becomes cloudy or otherwise contaminated, replace with fresh solution within 24 hours. Remove all other source of water if possible. Where a continuous source of infestation is present, permanent bait stations should be established and the bait replenished as needed. Supplement with cereal type anticoagulant baits. Solutions and dead rats should be picked up and disposed of upon completion of rodent control program.
	Burrow fumigation	Calcium cyanide 42 00 D.	Apply with foot pump. seal all exits.	Do not use in burrows which extend under buildings. Soil should not be extremely dry. Registered for military use only and for outdoor use only.
Woodchuck	Burrow fumigation	Calcium cyanide 42.00 D.	2 tablespoons placed 18-20 inches into burrow, or use foot pump. Cover all entrances.	Best when soil is damp. Ectoparasites will be killed also. Registered for military use only. For outdoor use only.

TABLE A-3

Chemical Control of Bats and Birds

DO NOT SUBSTITUTE THESE RECOMMENDATIONS FOR INFORMATION ON LABELS

PEST-STAGE	LOCATION-TYPE OF TREATMENT	PESTICIDE/ STOCK STRENGTH/FORM			APPLICATION: STRENGTH, RATE, AND METHOD			REMARKS
			Percent		Percent			
Bats	Roost-residual	No pesticides registered.						
	Roost-repellent	Naphthalene flakes	100.0	C.	100.0	C.	Apply 2.5 lb/1000 cu ft of attic scatter flakes on paper to permit retrieval of unused pesticide.	Bats may leave at once, but will return when repellent odor is gone. Immediate bat proofing is recommended to prevent reinfestation.
Blackbirds, Cowbirds, Sparrows	In or on nesting and roosting sites	Avitrol-R. N/S	0.5	B.	0.5	B.	ready-mixed on wheat or sorghum grain, mixed grains, or corn chops.	See note, below.
Blackbirds, Cowbirds, Starlings	As directed by trained personnel	Avitrol-R. N/S	1.0	B.	1.0	B.	ready-mixed on corn chops.	See note, below.
	Feedlots and poultry operations	Starlicide-R. N/S	1.0	B.		B.	Dilute Starlicide according to label.	See note, below. Not registered for cowbird control.
	In or on roosting sites	Compound PA-14 (Tergitol-R.) N/S	99.5				An avian stressing agent.	See note, below.
Crows	As directed by trained personnel	Avitrol-R. N/S	1.0	B.	1.0	B.	ready-mixed on whole corn grains.	See note, below.
Gulls	As directed by trained personnel	Avitrol-R. N/S	25.0 powder			B.	Consult label to prepare bread bait.	Gulls are protected by law and treaty. See note, below.
Pigeons (feral)	In or on nesting or roosting sites	Avitrol-R. N/S	0.5	B.	0.5	B.	ready-mixed on whole corn grains.	See note, below.
Sparrows	See "Blackbirds, Cowbirds, Sparrows", above.							
Starlings	Feedlots	Avitrol-R. N/S	1.0	P.	1.0	P.	Ready-mixed on pelletized bird feed.	See note, below.
			0.8	B.	0.8	B.	ready-mixed on corn chops and peanut butter.	
			50.0 powder			B.	Consult label to prepare bait.	
	Also see "Blackbirds, Cowbirds, Starlings", above.							
NOTE:	IT IS MANDATORY THAT USERS OF AVICIDES ACQUAINT THEMSELVES FIRST WITH LOCAL, STATE, AND FEDERAL REGULATIONS AND BE GUIDED BY THESE REGULATIONS IN ALL BIRD CONTROL ACTIVITIES.							

TABLE A-4

Specific Recommendations To Control Woody Plants in Seven Regions of the United States

DO NOT SUBSTITUTE THESE RECOMMENDATIONS FOR INFORMATION ON LABELS

Region[1]	Brush controlled	Chemical	Rate[2]	Remarks
1 & 2	Most brush	2,4,5-T	2 lb. per acre or 2 lb./100 gal. water (as a drenching spray)	
	Buckbrush and hazel	2,4-D	2 lb. per acre	In late May to mid-June
	Hard-to-kill species	2,4-D + 2,4,5-T	3 to 6 lb. in 10 to 25 gal. oil	Use as stem and foliage spray
	Elderberry, elm, eastern red cedar, sassafras, sumac, sweetgum, sycamore, walnut, wild plum, honeysuckle (top kill)	2,4-D + 2,4,5-T	8 lb. per acre	
3	Blackberries, brambles, common persimmon, prairie rose	2,4,5-T	3 to 4 lb. in 25 gal. oil + 75 gal. water	Drench foliage; use in late summer; avoid drift to cotton
	Buckbrush, skunkbrush	2,4-D	2 lb. per acre	-do-
4	Alder, bluejack, post and Turkey oak, persimmon	2,4,5-T	2 lb. per 100 gal. water	Drench foliage of Turkey oak in May or June; persimmon and post oak, in July and August
	Most deciduous upland hardwoods	2,4,5-T	2 lb. in 5 to 6 gal. oil-water emulsion per acre	Aerial spray
	Resistant species	2,4,5-T	4 lb. in 8 to 10 gal. per acre	Aerial spray
5	Willows and cottonwood	2,4-D + 2,4,5-T	3 to 4 lb. per 100 gal. of water	Drench foliage
	Chokecherries and wild rose	2,4,5-T	3 to 4 lb. per 100 gal. of water	Drench foliage
	Sagebrush	2,4-D	2 lb. per acre	

TABLE A-4 (Cont)

Specific Recommendations To Control Woody Plants in Seven Regions of the United States

Region[1]	Brush controlled	Chemical	Rate[2]	Remarks
6	Mesquite (original growth)	2,4,5-T	1/3 lb. per acre in oil-water emulsion	Use 1/2 to 3/4 lb. per acre on regrowth
	Mesquite (dense stands)	2,4,5-T	3/4 lb. in 2 gal. diesel fuel + 8 gal. water per acre	
	Shinnery oak	2,4,5-T	1/2 lb. in diesel fuel or oil-water emulsion	Apply annually for 3 years
	Post oak	2,4,5-T	2 lb. per acre in diesel fuel or oil-water emulsion	Apply 2 successive years
	Sand sagebrush	2,4-D	1 lb. per acre in diesel fuel or oil-water emulsion	
7	General spraying	2,4-D + 2,4,5-T	2 lb. in 1 gal. diesel fuel + water to make 40 gal. per acre	
	Coyote brush	-do-	-do- 10 gal. per acre	
	Willow	-do-	-do- 100 gal. per acre	
	Aerial spraying in California	-do-	2 to 4 lb. in 1 gal. diesel fuel + water to make 10 gal. per acre	
	Individual plants	-do-	4 lb. in 1 gal. diesel fuel + 98 gal. water	Drenching spray
	Deciduous trees	-do-	8 to 12 lb. in 98 gal. diesel oil	Thoroughly wet base of tree trunk
	Evergreens	-do-	4 lb. in 1 gal. diesel oil in 90 gal. water	Drenching spray

[1] See Figure 1 for regions.

[2] Rates given are for low-volatile ester formulations. If volatilization is likely, use an amine slat formulation in water and increase rate 50 per cent.

TABLE A-4 (Cont)

Herbicides for Treating Larger Trees and Brush

DO NOT SUBSTITUTE THESE RECOMMENDATIONS FOR INFORMATION ON LABELS

Method of application	Chemical and rate	Plants controlled	Remarks
Basal-bark (trunks less than 6" in diameter)	Ester of 2,4,5-T 12 to 16 lb. in 96 to 100 gal. diesel fuel	Most hardwood species	Cover all exposed bark just above ground line; let spray run down to bud zone; treat at anytime of year
Stump	Ester of 2,4-D or 2,4,5-T 12 to 16 lb. in 96 gal. diesel fuel	Most woody plants	Cover thoroughly the new wood of cut stump and bark to the ground; treat at anytime of year
	4 to 6 lb. AMS per gal. water	Ash, boxelder, cottonwood, maple, plum, willow	Use 1 tablespoon per 2 inches of diameter; spray or paint larger stumps; use crystals for stumps under 2 inches
Frills or girdles	Ester of 2,4,5-T or 2,4,5-T + 2,4-D 16 lb. per 100 gal. diesel fuel; amine salt of these herbicides in water is satisfactory in warm weather	Most woody plants	Treat at any time of year
	AMS 4 lb. per gal. of water	Ash, quaking aspen, hickory, maple, pecan, common persimmon, blackjack oak, post oak, red oak, sweet gum	
Cups or notches	AMS 1/2 oz. of crystals per notch or cup		Treat at anytime of year; space cups about 6 inches apart around trunk
Injections	Ester of 2,4,5-T; 33 lb. in 100 gal. diesel fuel; amine salt of 2,4,5-T in water is preferred in warm weather	For most hard woods	Treat at anytime of year
	Ester of 2,4,5-T + 2,4-D; 44 lb. in 100 gal. diesel fuel; amine salts of these herbicides are preferred in warm weather	-do-	Treat at anytime of year

TABLE A-4 (Cont)

Herbicides for Weed Control in Ornamental Plantings

DO NOT SUBSTITUTE THESE RECOMMENDATIONS FOR INFORMATION ON LABELS

Herbicide	Rate[1] per acre	Time of application	Weeds controlled	Remarks
Soil fumigants				
Calcium cyanamide	50 to 75 lb.[2]	Preplant	Weeds germinating in upper 4" of soil	Work into top soil; delay seeding 3-6 weeks
Metham	1 qt.[3]	Preplant	Most weeds	Work into soil; plant 14 to 30 days after treatment.
Methyl bromide	1 to 2 lb.[3]	Preplant	Most weeds	Use gastight cover; planting may be done 72 hours after cover is removed
Methyl bromide + chloropicrin	300 to 500 lb.	Preplant	Annual and perennial weeds and grasses	Use gastight cover 24 to 48 hours; seeding 48 to 72 hours after removal of cover; for transplanting, aereate for 7 to 10 days
Methyl isothiocyanate + chlorinated C_3 hydrocarbons	40 to 50 gal.	Preplant	General weed control	Use gastight cover; some weeds are controlled without cover
Selective herbicides				
Bensulide	10 to 15 lb.	After plants are established	Germinating crabgrass and other annual weed grasses	For well established plants
Cacodylic acid	1 to 2 gal.	Post emergence	General control of established weeds	Use as directed spray; inactivated on contact with soil
CDEC	4 to 6 lb.	Post planting in spring	Germinating annual weed grasses and some broadleaf weeds	Use as directed spray in established ornamentals

TABLE A-4 (Cont)

Herbicides for Weed Control in Ornamental Plantings

Herbicide	Rate[1] per acre	Time of application	Weeds controlled	Remarks
Selective herbicides – continued				
Chlorpropham	4 to 8 lb.	Preemergence	Germinating annual weed grasses and broadleaf weeds in conifers	Use as directed spray and avoid contact with base of plants
DCPA	9 to 12 lb.	Preemergence in early spring	Many germinating annual weed grasses and some broadleaf weeds	Do not disturb soil after application
Dichlobenil	4 to 6 lb.	Spring, late fall and early winter	Wide range of germinating grasses and broadleaf weeds	Use in established woody ornamentals
Dinoseb	2 lb. + 50 gal. aromatic oil	Post plant in early spring	Established and germinating annual weed grasses and annual broadleaf weeds	Use as a directed spray
Diphenamid	4 to 6 lb.	Preemergence	Many germinating annual weed grasses and some broadleaf weeds	Use in established plantings, either over top or directed spray
EPTC	3 to 6 lb.	Pre- or post plant	-do-	Must be soil incorporated
Naptalam	4 to 8 lb.	Before or after transplanting	-do-	Use in woody plants only; direct spray so as to strike nursery stock 3" or less above ground

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TABLE A-4 (Cont)

Herbicides for Weed Control in Ornamental Plantings

DO NOT SUBSTITUTE THESE RECOMMENDATIONS FOR INFORMATION ON LABELS

Herbicide	Rate[1] per acre	Time of application	Weeds controlled	Remarks
Selective herbicides – continued				
Norea	1 to 5 lb.	Preemergence	General; germinating weeds	May use in woody and herbaceous ornamentals; lasts 2 to 4 weeks
Paraquat	1 to 2 qt.	When weeds are young and succulent	Annual weeds and tops of perennial weeds	Use as directed spray; avoid drift
PCP	4 lb. + 50 gal. aromatic oil	Post plant in early spring	Established and germinating annual grass and broadleaf weeds	Use as directed spray
Prometryne	2 to 3 lb.	Preemergence	General, germinating weeds	May be used as directed spray, post emergence
Sesone	3 to 6 lb.	-do-	Germinating annual weed grasses and broadleaf weeds in conifers	Use as directed spray and avoid contact with base of plants
Simazine	2-1/2 to 5	In fall or spring before weeds emerge	Germinating annual weed grasses and broadleaf weeds, also quackgrass	For use in establishing woody ornamentals
Stoddard solvent	50 to 100 gal.	Post plant when weeds are up	General for established weeds	Use as directed spray on weed seedlings between rows
Terbacil	2 to 4 lb.	In spring before weeds emerge	Germinating annual grass and broadleaf weeds	Keep off foliage; do not use on lawns, walks, or driveways
Trifluralin	0.5 to 1 lb.	As preplant in ornamentals; when needed in established ornamentals	Germinating annual grass and some broadleaf weeds	Must be soil incorporated; long range control

[1] Rates and *concentrations* are in terms of acid equivalent or active ingredients, not necessarily of commercial formulation.

[2] Rate for 1,000 square feet.

[3] Rate for 100 square feet.

TABLE A-4 (Cont)

Herbicides for Weed Control in Lawns and Turf

DO NOT SUBSTITUTE THESE RECOMMENDATIONS FOR INFORMATION ON LABELS

Herbicide	Rate per acre[1]	Time of application	Weeds controlled	Remarks
Grass and broadleaf weeds				
Calcium cyanamide	2,200 lb.[2]	3 weeks before seeding		Work into a moist and well prepared seed bed
DCPA	10 to 12 lb.	Early to mid-April	Crabgrass and many other annual grasses	For professional turf management; do not use on dichondra; do not seed for 3 months after treatment
Diphenamid	8 to 20 lb.	Fall and spring		For dichondra lawns
Endothall	2 lb.	When moisture favors good turf growth	Burclover, henbit, knotweed, pennywort	Temporary turf browning if air temperature is over 80°F., and dry
Metham	114 gal.	Preplanting		Put on well prepared and fine seed bed; can seal in with water without a cover; lasts about 2 weeks
Methyl bromide	454 lb.	When air and soil temperatures are above 65°F.	Most species	May seed 2 to 3 days after treatment; poisonous, extra precautions necessary
Methyl bromide + chloropicrin	500 to 600 lb.	-do-	Most species	Inject into the soil and cover with gas tight cover within 20 minutes; poisonous, extra precautions necessary; follow directions on label
Methyl isothiocynate + chlorinated C_3 hydrocarbons	28 to 57 gal.	-do-		Cover with gas tight cover for 1 week; poisonous, extra precautions necessary

TABLE A-4 (Cont)

Herbicides for Weed Control in Lawns and Turf

DO NOT SUBSTITUTE THESE RECOMMENDATIONS FOR INFORMATION ON LABELS

Herbicide	Rate per acre[1]	Time of application	Weeds controlled	Remarks
Grass and broadleaf weeds – continued				
Paraquat	1 lb.	When weeds are in 3 to 5 leaf stage		Prepare seed bed first and let weed growth start; after treatment, seed with little soil disturbance; always use an appropriate surfactant
Grass weeds				
AMA	5 to 6 lb.	Summer	Mostly for crabgrass	If temperature is over 80°F. reduce rate of application
Benefin	2 to 3 lb.	Before germination of annual grasses		Do not use on bent-grass putting greens; may reseed within 3 months after treatment
Bensulide	10 to 20 lb.		Mostly for crabgrass	Apply to established turf only; do not overseed within 6 months after treatment
Dalapon	10 lb.	Through season on actively growing grass	Perennial grasses	Will injure all grasses; both spot treatment and preplant; repeat applications may be needed; seed lawn 3 to 4 weeks after last treatment
DSMA	3 to 6 lb.	Spring and early summer	Crabgrass, dallisgrass sandbur, foxtails, Johnsongrass seedlings and others; also, chickweed	May need 1 to 3 applications at 7 to 10 day intervals; do not use on St. Augustine or centipede grass
MSMA	3 to 6 lb.	-do-	-do-	-do-
Petroleum naptha	44 gal.	When grasses are in active growth	Clumps of some grass weeds	Use with care as a direct spray; will injure lawn grasses

TABLE A-4 (Cont)

Herbicides for Weed Control in Lawns and Turf

DO NOT SUBSTITUTE THESE RECOMMENDATIONS FOR INFORMATION ON LABELS

Herbicide	Rate per acre[1]	Time of application	Weeds controlled	Remarks
		Grass weeds – continued		
Siduron	10 lb.	Before weed seeds germinate	Does not control annual bluegrass; will control crabgrass, foxtails, and downy brome grass	Treat before, after, or during seeding, water within 3 days if it does not rain; use on bluegrass and fescue lawns; check susceptibility on other lawn species
Terbutol	10 to 20 lb.	Before germination	For crabgrass control	Use in established lawns; do not overseed within 6 months after treatment
		Broadleaf weeds		
Dicamba	1/2 to 1 lb.	When weeds are in active growth	Red sorrel, knot weed, clovers, chickweed, and others	Keep away from root zone of trees and ornamentals; usually mixed with 2,4-D for spraying; use no more than 1/4 lb./A in lawns
Silvex	3/4 to 1 lb.	While weeds are small	Especially chickweed, ground ivy, and henbit	Apply when there is ample moisture and air temperature of 75°F. or more
2,4-D	1 to 1-1/2 lb.	When weeds are in active growth	Many species	Choose bright days with temperature near 70°F.; do not mow for 24 to 48 hours
2,4-D amine salt or low volatile ester plus detergent	1 to 2 lb.	Late winter or early spring	Knotweed, wild garlic, and wild onion	Follow directions on label; repeated annual treatments for wild garlic

TABLE A-4 (Cont)

Herbicides for Weed Control in Lawns and Turf

DO NOT SUBSTITUTE THESE RECOMMENDATIONS FOR INFORMATION ON LABELS

Herbicide	Rate per acre[1]	Time of application	Weeds controlled	Remarks
Broadleaf weeds – continued				
2,4-D plus dicamba or silvex	0.25 + 2 lb.	When weeds are small	Chickweed, clover, henbit, knotweed, and red sorrel	Do not exceed recommended rate; protect trees, shrubs, and flowers by spraying in root zone of shrubs; prevent drift

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[1] Pounds of active ingredient.

TABLE A-4 (Cont)

Herbicides To Control Aquatic Weeds

DO NOT SUBSTITUTE THESE RECOMMENDATIONS FOR INFORMATION ON LABELS

Herbicide	Rate of application[1]	Time of application	Weeds controlled	Remarks
Perennial sedges on irrigation and drainage ditchbanks				
Amitrole or amitrole-T	5 to 20 lb./A	On young growth before heading	Tall sedges	Repeat every 6 to 8 weeks as needed; use only in drainage ditches or marshes; do not contaminate irrigation or potable water supplies
Dalapon	15 lb/A	On young growth 10 to 15" tall	-do-	Repeat every 6 to 8 weeks as needed; may be used in water supply reservoirs provided the concentration does not exceed 0.1 mg/l in the reservoir; may be used in irrigation water provided the sodium content of the irrigated soil is not critical.
Fuel oil with dinoseb	100 to 160 gal./A	-do-	-do-	Use 2 to 3 pts. of dinoseb per 100 gal. of fuel oil; avoid contamination of irrigation or potable water
2,4-D	6 to 8 lb./A	-do-	-do-	Repeat as necessary; avoid contamination of irrigation or potable water
Floating weeds (unattached, tops above water)				
Amitrol-T	1 to 1.5 lb./A	When actively growing	Water hyacinth	Use only in drainage ditch or marshes; do not use treated water for domestic or irrigation purposes except as specified on the label
Diquat (cation)	0.5 to 1 p.p.m. 1 to 1.5 lb./A	Time of active growth	Duckweed, water hyacinth, water lettuce	Inject in water or spray on foliage; do not use treated water for ten days after treatment
Silvex (ester)	8 lb./A	At first bloom	Alligatorweed	Repeat, 2 to 4 applications as needed; do not use treated water for domestic purposes except as specified on the label
2,4-D amine salts	2 to 4 lb./A	When weeds are in active growth	General control alligatorweed, duckweed, waterfern, water lettuce	Repeat every 4 to 5 weeks as needed; include oil and emulsifier for duckweed and water lettuce. Do not use treated water except as specified on the label

TABLE A-4 (Cont)

Herbicides To Control Aquatic Weeds

DO NOT SUBSTITUTE THESE RECOMMENDATIONS FOR INFORMATION ON LABELS

Herbicide	Rate of application[1]	Time of application	Weeds controlled	Remarks
Emersed and marginal weeds (rooted under water, tops above water, or growing on wet soil)				
Amitrole	6 to 12 lb./A	Fully headed or post heading stage	Bulrushes and cattails	Use only in drainage ditches or marshes; do not use contaminated water for domestic or irrigation purposes
Amitrole or amitrole-T	8 to 16 lb./A	On young growth before heading	Perennial grasses and sedges	Apply in 100 to 400 gal. water as a ground spray; 10 to 15 gal. water as an aerial spray; use only in drainage ditches or marshes; do not use treated water for domestic or irrigation purposes
Dalapon	15 to 30 lb./A	-do-	Cattails	Apply in 100 to 400 gal. water as a ground spray; 10 to 15 gal. water as an aerial spray; may be used in water supply reservoirs provided the concentration does not exceed 0.1 mg/1 in the reservoir; may be used in irrigation water provided the sodium content of the irrigated soil is not critical.
	20 to 30 lb./A	-do-	Perennial grasses and sedges	
Silvex (ester)	8 lb./A	At first bloom	Rooted, emersed alligatorweed	Apply 2 to 4 applications as needed in 150 to 200 gal. water per acre; do not use treated water for domestic or irrigation purposes except as specified on label
2,4-D (low-volatile esters)	4 to 6 lb./A	At first heading	Bulrushes and cattails	Apply in 1:20 oil-water emulsion at 150 to 200 gal. per acre; precautions as above
2,4-D (low-volatile esters)	1 to 4 lb./A	-do-	Arrowhead, white water lily, and other plants with waxy leaves	Apply in oil or oil-water emulsion (1:10 or 1:20); precautions as above
2,4-D, or silvex	2 to 4 lb./A	When weeds are actively growing	General for broadleaf weeds	Spray in 200 gal. water per acre; precautions as above

TABLE A-4 (Cont)

Herbicides To Control Aquatic Weeds

DO NOT SUBSTITUTE THESE RECOMMENDATIONS FOR INFORMATION ON LABELS

Herbicide	Rate of application[1]	Time of application	Weeds controlled	Remarks
Submersed weeds (tops mostly under water, usually rooted or anchored) In ponds, lakes, and reservoirs				
Copper sulfate (pentahydrate, dark blue)	0.1 to 0.5 p.p.m.w.	Early stage of growth	Algae, blue-green	Apply as crystals or powder; repeat as necessary
Copper Sulfate	0.5 to 1 p.p.m.w.	-do-	Algae, filamentous	In soft water, safe on most fish except trout; safe in potable water
Copper sulfate (pentahydrate, dark blue)	1 to 2 p.p.m.w.	-do-	-do-	In hard water, injurious to most fish; safe in potable water
Dichlobenil	7 to 10 lb./A	-do-	Rooted or anchored weeds	Follow directions on label. Do not use treated water for domestic or irrigation purposes.
	10 to 15 lb./A	When new growth starts	-do-	Broadcast on water surface; use heavier rate if water is more than 3' deep
Diquat (cation)	0.5 to 1.5 p.p.m.w.	-do-	Rooted or anchored weeds except elodea and wild celery	Apply on the surface or inject below; do not use treated water for domestic or irrigation purposes for 10 days after treatment
Endothall (diemthylaikylamine salts)	0.05 to 0.2 p.p.m.w.	-do-	Filamentous algae	Apply on the surface or inject below; do not use treated water for domestic or irrigation purposes for 7 days after treatment
	0.5 to 2.5 p.p.m.w.	-do-	Rooted or anchored weeds except chara	For spot treatment or where some fish kill is not objectionable; precautions as above
Endothall (disodium salt)	1 to 4 p.p.m.w.	-do-	-do-	Consult fish and wild life specialists before use; precautions as above

TABLE A-4 (Cont)

Herbicides To Control Aquatic Weeds

DO NOT SUBSTITUTE THESE RECOMMENDATIONS FOR INFORMATION ON LABELS

Herbicide	Rate of application[1]	Time of application	Weeds controlled	Remarks
Submersed weeds (tops mostly under water, usually rooted or anchored) In Ponds, Lakes, and Reservoirs – continued				
Fenac	15 to 20 lb./A	When lake bottom or shorelines are exposed	-do-	Keep water down for at least 3 weeks; do not use treated water for domestic or irrigation purposes
2,4-D (ester) (granule or pellet form)	20 to 40 lb./A	-do-	-do- except elodea, wild celery, and some pond weeds	Toxic to some fish; apply to surface of water. Do not use treated water for domestic or irrigation purposes.
Silvex (potassium salt)	1.5 to 2 p.p.m.w. or 5 lb./A. ft.	-do-	-do-	Apply to surface or inject below water surface. Do not use treated water for domestic or irrigation purposes.
Irrigation and drainage canals–flowing water				
Acrolein	1 to 2.5 gal. c.f.s.	When weed infestation starts	All species of algae and submersed weeds	Use special equipment; apply below surface; toxic to fish; do not use treated water for domestic purposes
	0.1 to 0.6 p.p.m.w.	-do-	-do-	Inject into large canals (200 to 2,000 or more c.f.s.) at one location for 8 to 48 hours
Aromatic solvents (xylene)	8 to 10 gal. c.f.s. (300 to 740 p.p.m.w. in 30 to 60 minutes)	Before weeds become matted	Most submersed species except water plantain	Avoid fire hazard; treat water at intervals of 2 to 4 miles down canal. Do not use treated water for domestic purposes.
Irrigation and drainage canals–flow stopped or greatly reduced				
Acrolein	4 to 7 p.p.m.w.	-do-	-do-	Apply below surface; toxic to fish; do not use treated water for domestic purposes

TABLE A-4 (Cont)

Herbicides To Control Aquatic Weeds

DO NOT SUBSTITUTE THESE RECOMMENDATIONS FOR INFORMATION ON LABELS

Herbicide	Rate of application[1]	Time of application	Weeds controlled	Remarks
Irrigation and drainage canals—flow stopped or greatly reduced – continued				
Diquat (cation)	0.25 to 1.5 p.p.m.w.	When weed starts to grow	Most submersed weeds	Apply above or below surface; allow at least 12 hours exposure; do not use treated water for domestic or irrigation purposes for 14 days after treatment
Endothall (dimethylalkylamine salt)	1.5 to 4 p.p.m.w.	-do-	-do-	Apply above or below surface; toxic to fish; do not use treated water for domestic or irrigation purposes for 14 days after treatment
Reservoirs and large canals carrying potable water				
Copper Sulfate (pentahydrate)	0.6 to 1 p.p.m.w.	Continuous during growing season	Most algae and submersed weeds	Heavy applications early in season; reduce as water temperature rises
"Slug" treatments	0.33 to 2 lb./c.f.s.	Periodically during growing season	-do-	Light rates for soft water; crystals dissolve very slowly; may be suspended in burlap bags

[1] Rates and concentrations are in terms of acid equivalent or active ingredient, and not necessarily, or usually, of commercial formulation.

CONTENTS

Page	*Key*
B-1	MOSQUITOES: Pictorial key to some common adults (female) of the United States
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B-3	FLEAS: Pictorial key to some common species in the United States
B-4	TICKS: Pictorial key to some common species
B-5	MITES: Pictorial key to some common species of public health importance
B-6	SCORPIONS: Pictorial key to some common United States species
B-7	MILLIPEDES: Key to some important United States species
B-8	CENTIPEDES: Key to some important United States species
B-9	SNAKES: Key to venomous species in the United States
B-13	COCKROACHES: Pictorial key to some common species
B-14	ANTS: Key to some common species
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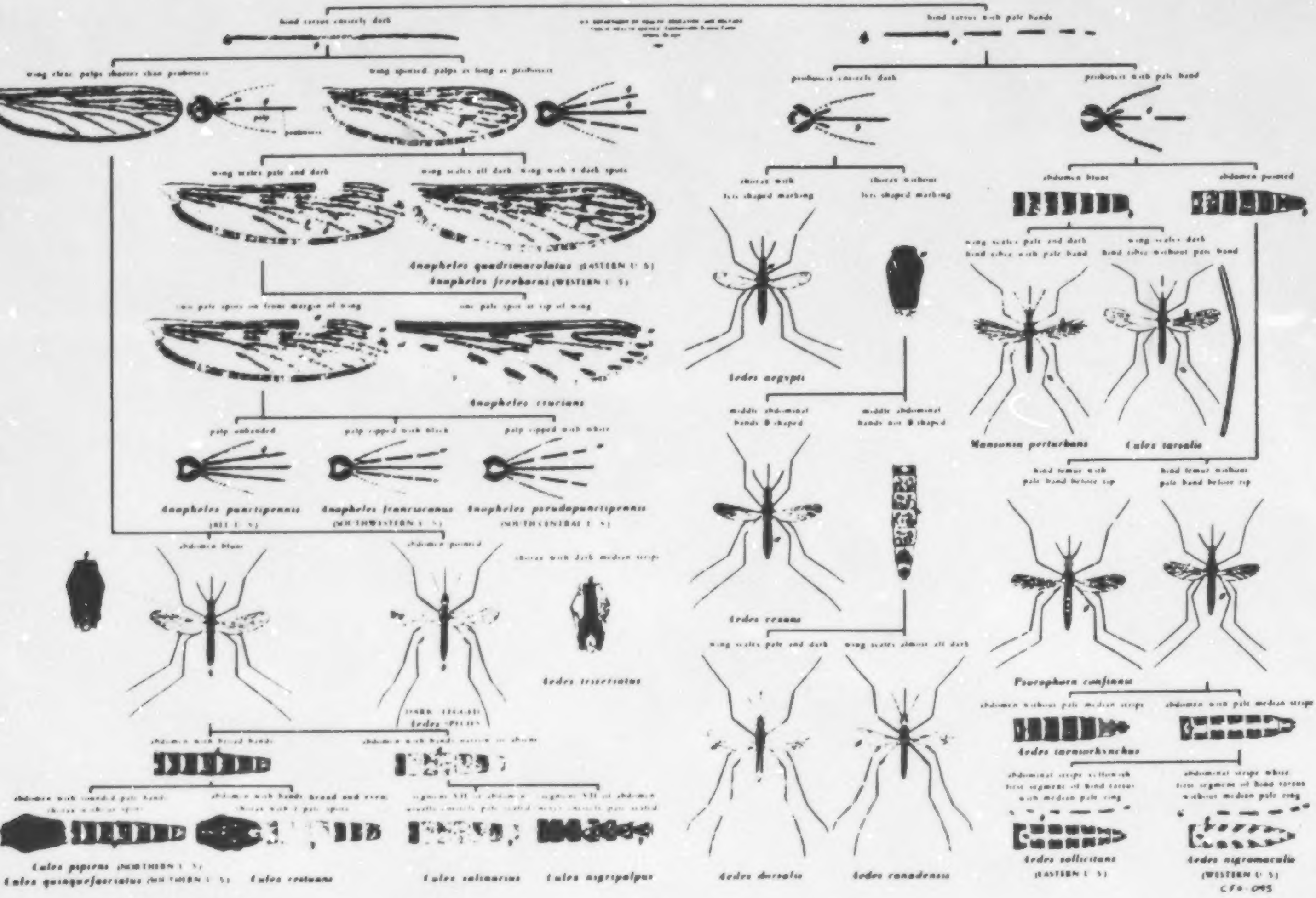
B-16	BEETLES: Pictorial key to some species commonly associated with stored foods

APPENDIX B

IDENTIFICATION KEYS TO SOME IMPORTANT ARTHROPODS, REPTILES, BIRDS, AND MAMMALS

MOSQUITOES: PICTORIAL KEY TO SOME COMMON ADULTS (FEMALE) OF THE UNITED STATES


hind tarsus entirely dark
hind tarsus with pale bands
wing clear, palps shorter than proboscis
palp
proboscis
wing spotted, palps as long as proboscis
proboscis entirely dark
proboscis with pale band
wing scales pale and dark
wing scales all dark, wing with 4 dark spots
Anopheles quadrimaculatus (EASTERN U. S.)
Anopheles freeborni (WESTERN U. S.)
two pale spots on front margin of wing
one pale spot at tip of wing
Anopheles crucians
palp unbanded
palp tipped with black
palp tipped with white
Anopheles punctipennis
(ALL U. S.)
Anopheles franciscanus
(SOUTHWESTERN U. S.)
Anopheles pseudopunctipennis
(SOUTHCENTRAL U. S.)
thorax with lyre-shaped marking
thorax without lyre-shaped marking
Aedes aegypti
abdomen blunt
abdomen pointed
wing scales pale and dark
hind tibia with pale band
wing scales dark
hind tibia without pale band
Mansonia perturbans
Culex tarsalis
middle abdominal bands B-shaped
middle abdominal bands not B-shaped
Aedes vexans
hind femur with pale band before tip
hind femur without pale band before tip
abdomen blunt
abdomen pointed
thorax with dark median stripe
Aedes triseriatus
DARK - LEGGED
Aedes SPECIES
Psorophora confinnis
wing scales pale and dark
wing scales almost all dark
abdomen with broad bands
abdomen with bands narrow or absent
abdomen without pale median stripe
abdomen with pale median stripe
Aedes taeniorhynchus
abdomen with rounded pale bands
thorax without spots
abdomen with bands broad and even
thorax with 2 pale spots
segment VIII of abdomen usually entirely pale scaled
segment VIII of abdomen mostly entirely dark scaled
abdominal stripe yellowish
first segment of hind tarsus with median pale ring
abdominal stripe white
first segment of hind tarsus without median pale ring
Culex pipiens (NORTHERN U. S.)
Culex quinquefasciatus (SOUTHERN U. S.)
Culex restuans
Culex salinarius
Culex nigripalpus
Aedes dorsalis
Aedes canadensis
Aedes sollicitans
(EASTERN U. S.)
Aedes nigromaculis
(WESTERN U. S.)
CFA-095

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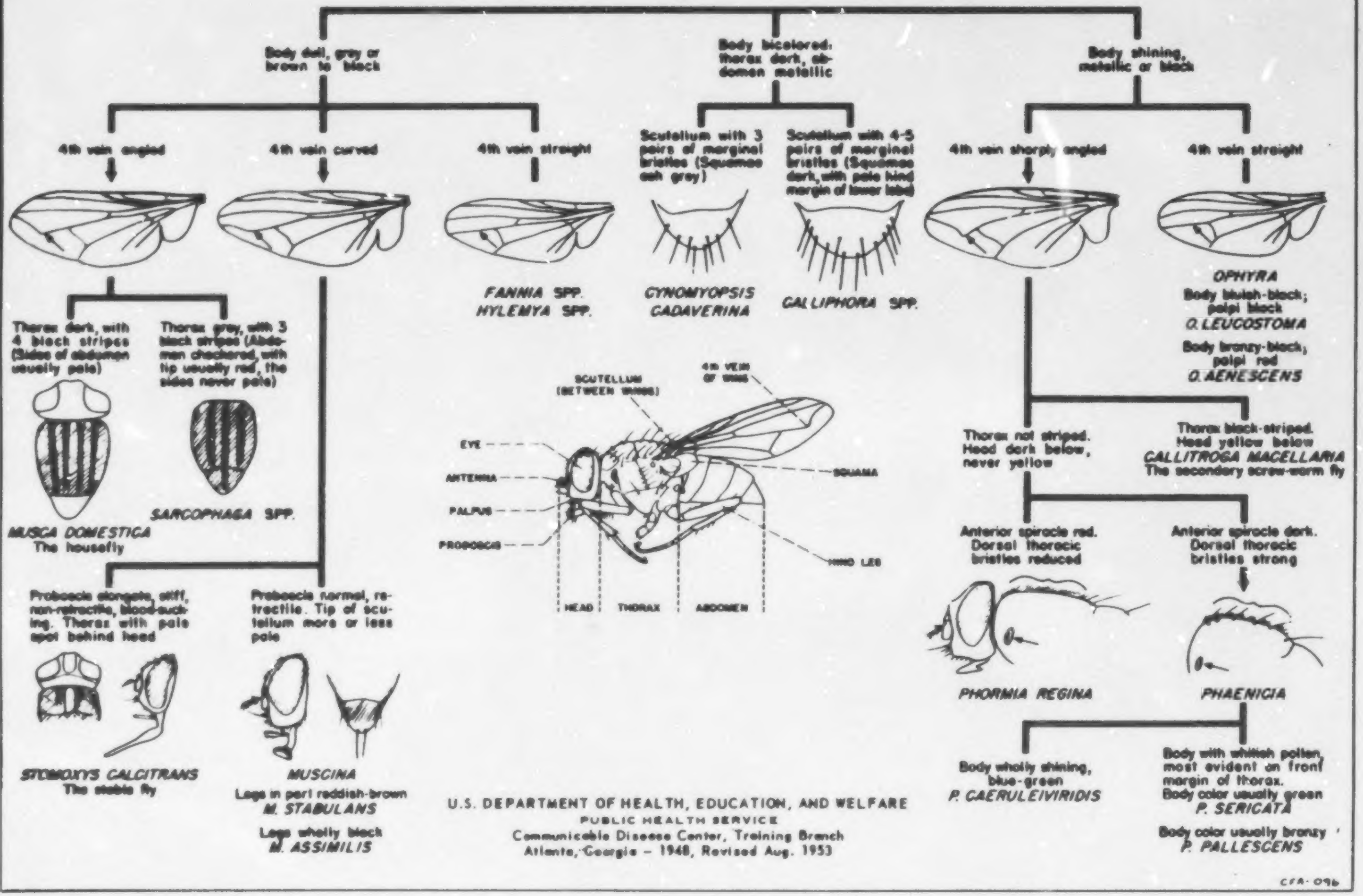
DOMESTIC FLIES: PICTORIAL KEY TO COMMON SPECIES IN SOUTHERN U.S.


Body dull, grey or brown to black
Body bicolored: thorax dark, abdomen metallic
Body shining, metallic or black
4th vein angled
4th vein curved
4th vein straight
Scutellum with 3 pairs of marginal bristles (Squamae ash grey)
Scutellum with 4-5 pairs of marginal bristles (Squamae dark, with pale hind margin of lower lobe)
4th vein sharply angled
4th vein straight
FANNIA SPP.
HYLEMYA SPP.
CYNOMYOPSIS CADAVERINA
CALLIPHORA SPP.
OPHYRA
Body bluish-black; palpi black
O. LEUCOSTOMA
Body bronzy-black, palpi red
O. AENESCENS
Thorax dark, with 4 black stripes (Sides of abdomen usually pale)
Thorax grey, with 3 black stripes (Abdomen checkered, with tip usually red, the sides never pale)
MUSCA DOMESTICA
The housefly
SARCOPHAGA SPP.
SCUTELLUM (BETWEEN WINGS)
4th VEIN OF WING
EYE
ANTENNA
PALPUS
PROBOSCIS
SQUAMA
HIND LEG
HEAD
THORAX
ABDOMEN
Thorax not striped. Head dark below, never yellow
Thorax black-striped. Head yellow below
CALLITROGA MACELLARIA
The secondary screw-worm fly
Anterior spiracle red. Dorsal thoracic bristles reduced
Anterior spiracle dark. Dorsal thoracic bristles strong
PHORMIA REGINA
PHAENICIA
Proboscis elongate, stiff, non-retractile, blood-sucking. Thorax with pale spot behind head
Proboscis normal, retractile. Tip of scutellum more or less pale
STOMOXYS CALCITRANS
The stable fly
MUSCINA
Legs in part reddish-brown
M. STABULANS
Legs wholly black
M. ASSIMILIS
Body wholly shining, blue-green
P. CAERULEIVIRIDIS
Body with whitish pollen, most evident on front margin of thorax. Body color usually green
P. SERICATA
Body color usually bronzy
P. PALLESCENS

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
Communicable Disease Center, Training Branch
Atlanta, Georgia – 1948, Revised Aug. 1953

CFA-096

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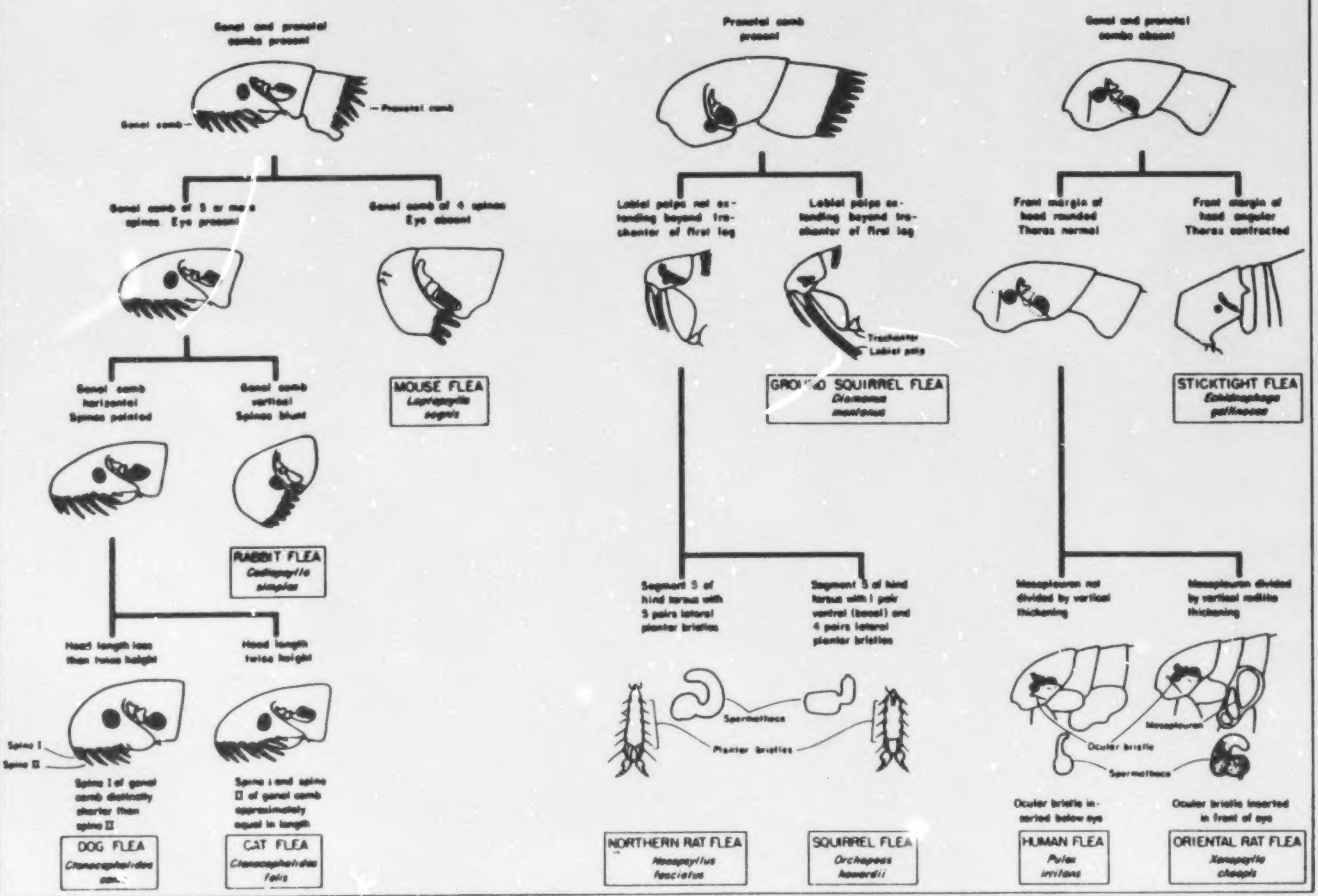
FLEAS: PICTORIAL KEY TO SOME COMMON SPECIES IN THE UNITED STATES


Genal and pronotal combs present
Genal comb
Pronotal comb
Genal comb of 5 or more spines. Eye present
Genal comb of 4 spines Eye absent
MOUSE FLEA
Leptopsylla segnis
Genal comb horizontal Spines pointed
Genal comb vertical Spines blunt
RABBIT FLEA
Cediopsylla simplex
Head length less than twice height
Head length twice height
Spine I
Spine II
Spine I of genal comb distinctly shorter than spine II
Spine I and spine II of genal comb approximately equal in length
DOG FLEA
Ctenocephalides canis
CAT FLEA
Ctenocephalides felis
Pronotal comb present
Labial palps not extending beyond trochanter of first leg
Labial palps extending beyond trochanter of first leg
Trochanter
Labial palp
GROUND SQUIRREL FLEA
Diamanus montanus
Segment 5 of hind tarsus with 5 pairs lateral plantar bristles
Segment 5 of hind tarsus with 1 pair ventral (basal) and 4 pairs lateral plantar bristles
Spermatheca
Plantar bristles
NORTHERN RAT FLEA
Nosopsyllus fasciatus
SQUIRREL FLEA
Orchopeas howardii
Genal and pronotal combs absent
Front margin of head rounded Thorax normal
Front margin of head angular Thorax contracted
STICKTIGHT FLEA
Echidnophaga gallinacea
Mesopleuron not divided by vertical thickening
Mesopleuron divided by vertical rodlike thickening
Mesopleuron
Ocular bristle
Spermatheca
Ocular bristle inserted below eye
Ocular bristle inserted in front of eye
HUMAN FLEA
Pulex irritans
ORIENTAL RAT FLEA
Xenopsylla cheopis

CFA-047

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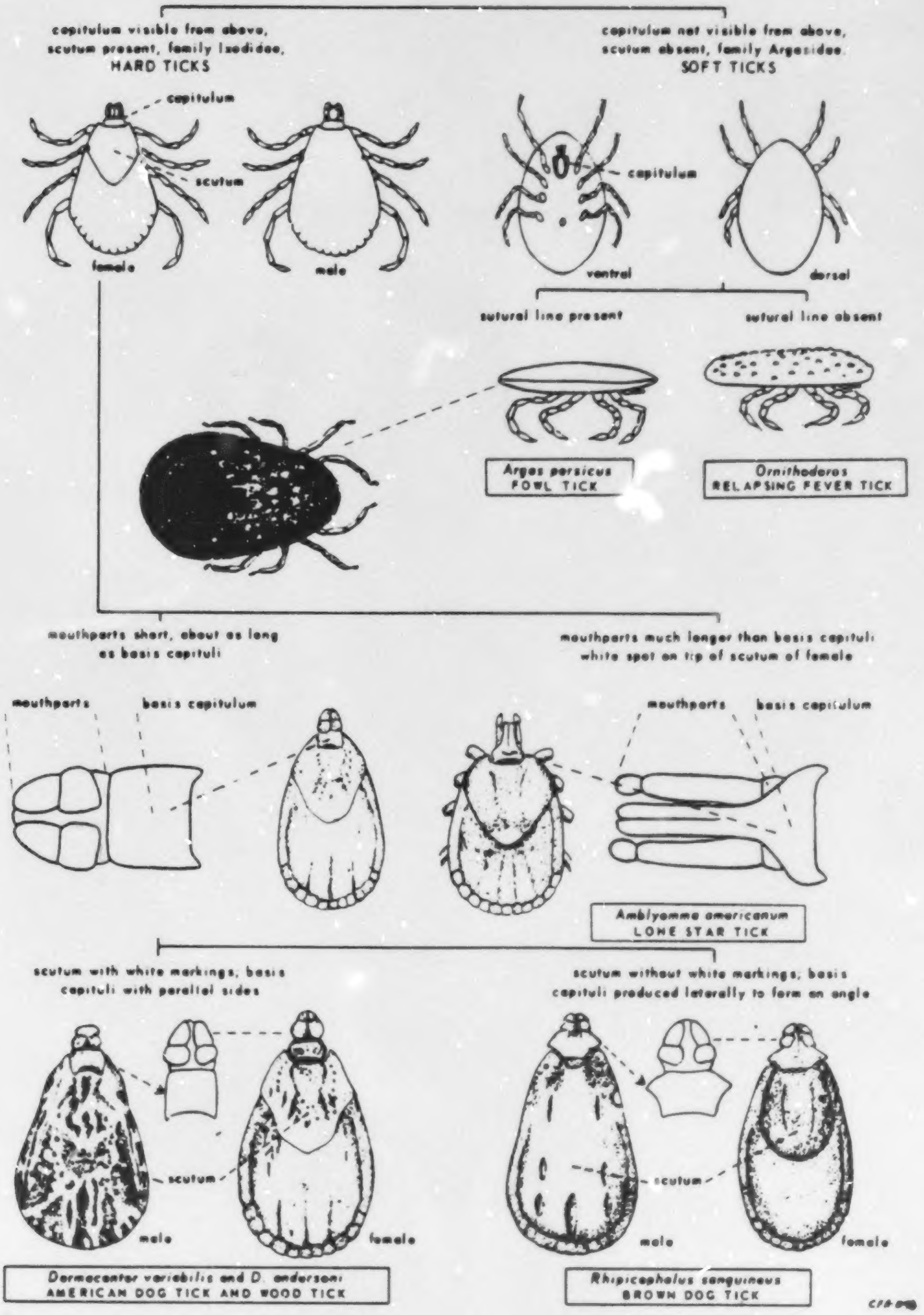
TICKS: PICTORIAL KEY TO SOME COMMON SPECIES


capitulum visible from above,
scutum present, family Ixodidae,
HARD TICKS
capitulum not visible from above,
scutum absent, family Argasidae.
SOFT TICKS
capitulum
scutum
female
male
capitulum
ventral
dorsal
sutural line present
sutural line absent
Argas persicus
FOWL TICK
Ornithodoros
RELAPSING FEVER TICK
mouthparts short, about as long
as basis capituli
mouthparts much longer than basis capituli
white spot on tip of scutum of female
mouthparts
basis capitulum
mouthparts
basis capitulum
Amblyomma americanum
LONE STAR TICK
scutum with white markings, basis
capituli with parallel sides
scutum without white markings; basis
capituli produced laterally to form an angle
scutum
male
female
Dermacentor variabilis and D. andersoni
AMERICAN DOG TICK AND WOOD TICK
scutum
male
female
Rhipicephalus sanguineus
BROWN DOG TICK
CFR-0910

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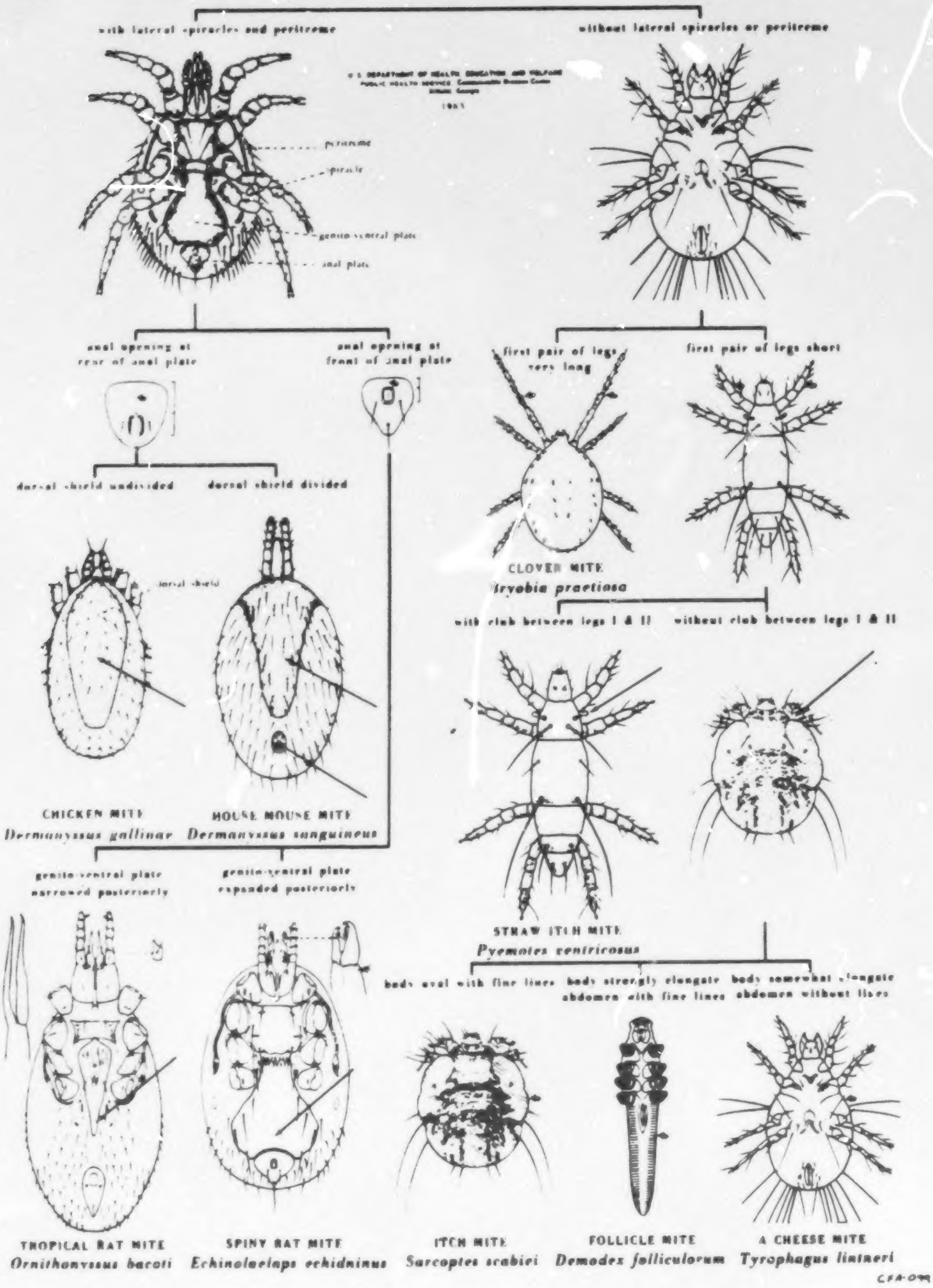
MITES: PICTORIAL KEY TO SOME COMMON SPECIES OF PUBLIC HEALTH IMPORTANCE


with lateral spiracles and peritreme
without lateral spiracles or peritreme
U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE Communicable Disease Center
Atlanta, Georgia
peritreme
spiracle
genito-ventral plate
anal plate
anal opening at rear of anal plate
anal opening at front of anal plate
first pair of legs very long
first pair of legs short
dorsal shield undivided
dorsal shield divided
dorsal shield
CLOVER MITE
Bryobia praetiosa
with club between legs I & II
without club between legs I & II
CHICKEN MITE
Dermanyssus gallinae
HOUSE MOUSE MITE
Dermanyssus sanguineus
genito-ventral plate narrowed posteriorly
genito-ventral plate expanded posteriorly
STRAW ITCH MITE
Pyemotes ventricosus
body oval with fine lines
body strongly elongate abdomen with fine lines
body somewhat elongate abdomen without lines
TROPICAL RAT MITE
Ornithonyssus bacoti
SPINY RAT MITE
Echinolaelaps echidninus
ITCH MITE
Sarcoptes scabiei
FOLLICLE MITE
Demodex folliculorum
A CHEESE MITE
Tyrophagus lintneri
CFA-099

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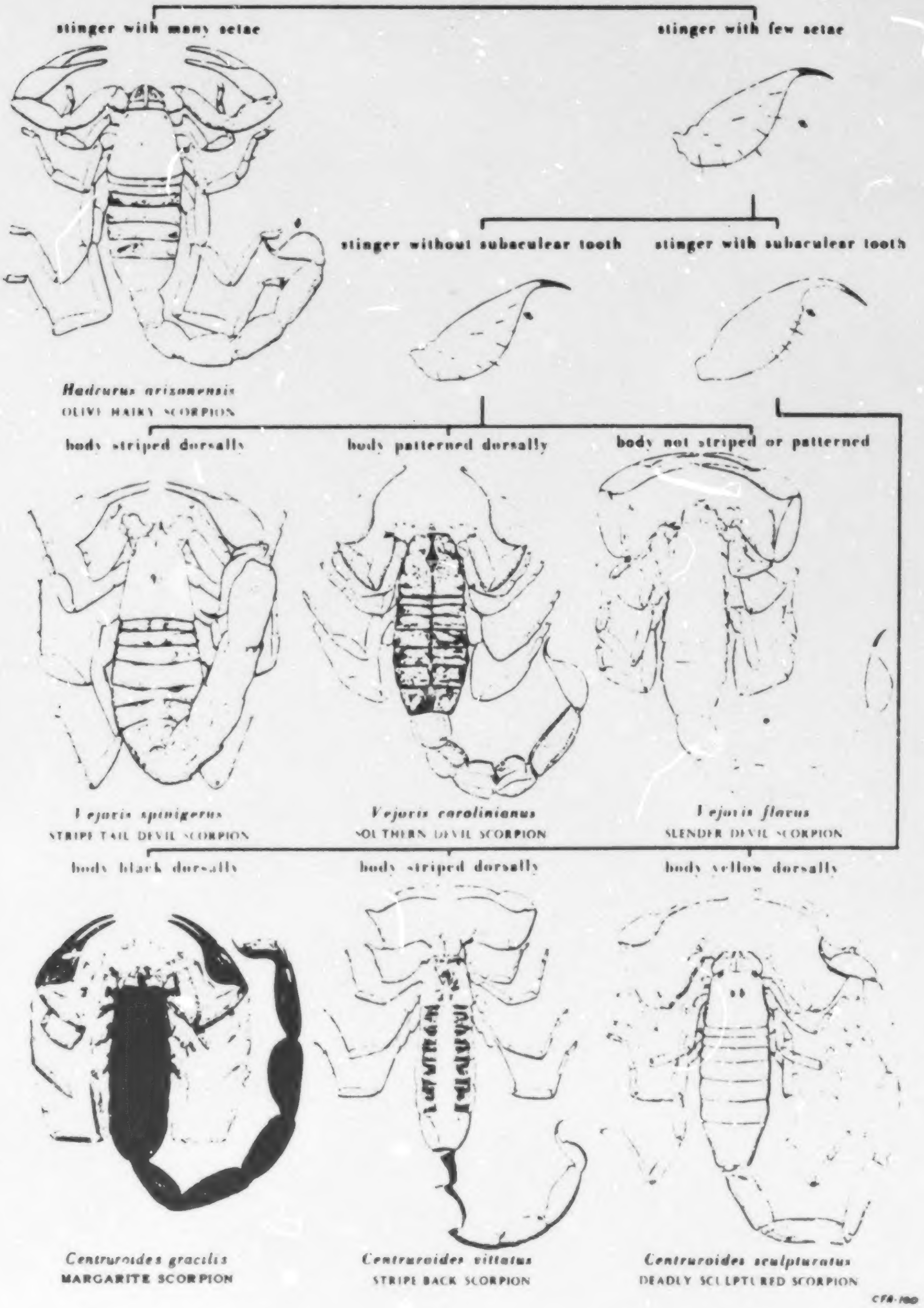
SCORPIONS: PICTORIAL KEY TO SOME COMMON UNITED STATES SPECIES


stinger with many setae
stinger with few setae
stinger without subaculear tooth
stinger with subaculear tooth
Hadrurus arizonensis
OLIVE HAIRY SCORPION
body striped dorsally
body patterned dorsally
body not striped or patterned
Vejovis spinigerus
STRIPE TAIL DEVIL SCORPION
Vejovis carolinianus
SOUTHERN DEVIL SCORPION
Vejovis flavus
SLENDER DEVIL SCORPION
body black dorsally
body striped dorsally
body yellow dorsally
Centruroides gracilis
MARGARITE SCORPION
Centruroides vittatus
STRIPE BACK SCORPION
Centruroides sculpturatus
DEADLY SCULPTURED SCORPION
CFA-100

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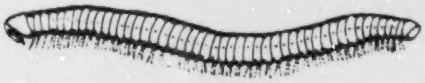
MILLIPEDES: KEY TO SOME IMPORTANT UNITED STATES SPECIES

1. 20-21 body segments 2

   More than 29 body segments 3

2. Legs with basal spines . . . . *Pleurolomia butleri* (= *Fontaria virginiensis*)

   Legs without basal spines . . . . *Pseudopolydesmus serratus*

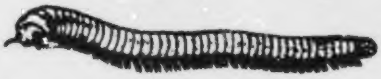


Narceus americanus

3. Body segment 3 with legs . . . . *Narceus americanus* (= *Spirobolus marginatus*)

   Body segment 3 without legs . . . . *Brachyiulus pusillus* (= *Julus virgatus*)

Brachyiulus pusillus



CFB-101

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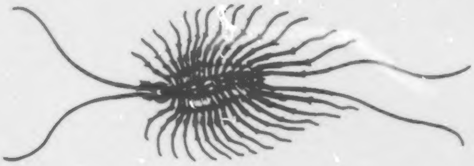
CENTIPEDES: KEY TO SOME IMPORTANT UNITED STATES SPECIES

1. 8 dorsal plates: 15 pairs of long legs. . . . EASTERN HOUSE CENTIPEDE, *Scutigera cleoptrata*

More than 14 dorsal plates. 2



Scutigera cleoptrata

2. 15 pairs of legs (*Lithobius*). 3

21-23 pairs of legs (*Scolopendra*) 4

More than 30 pairs of legs (*Geophilus*) . . . . [illegible]

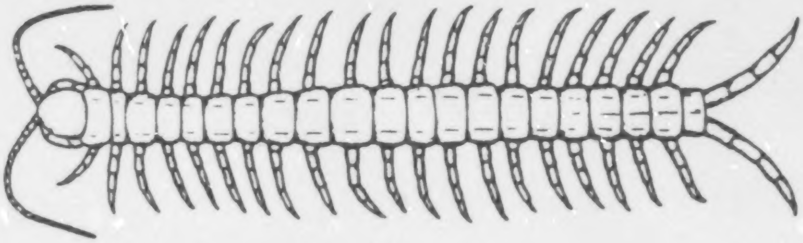
3. Antenna 19-23 segmented . . . .*Lithobius multidentatus*

Antenna 33-43 segmented . . . . *Lithobius forficatus*

4. Anal legs as long as or longer than 3 terminal body segments. . . . .

. . . . WESTERN HOUSE CENTIPEDE, *Scolopendra heros*

Anal legs shorter than 3 terminal body segments . . . . *Scolopendra morsitans*



Scolopendra heros

5. 47-53 pairs of legs. 6

64-67 pairs of legs. . . . . *Geophilus californicus*

6. With 2 longitudinal black lines . . . .*Geophilus rubens*

Without longitudinal black lines . . . .*Geophilus umbraticus* CFA-102

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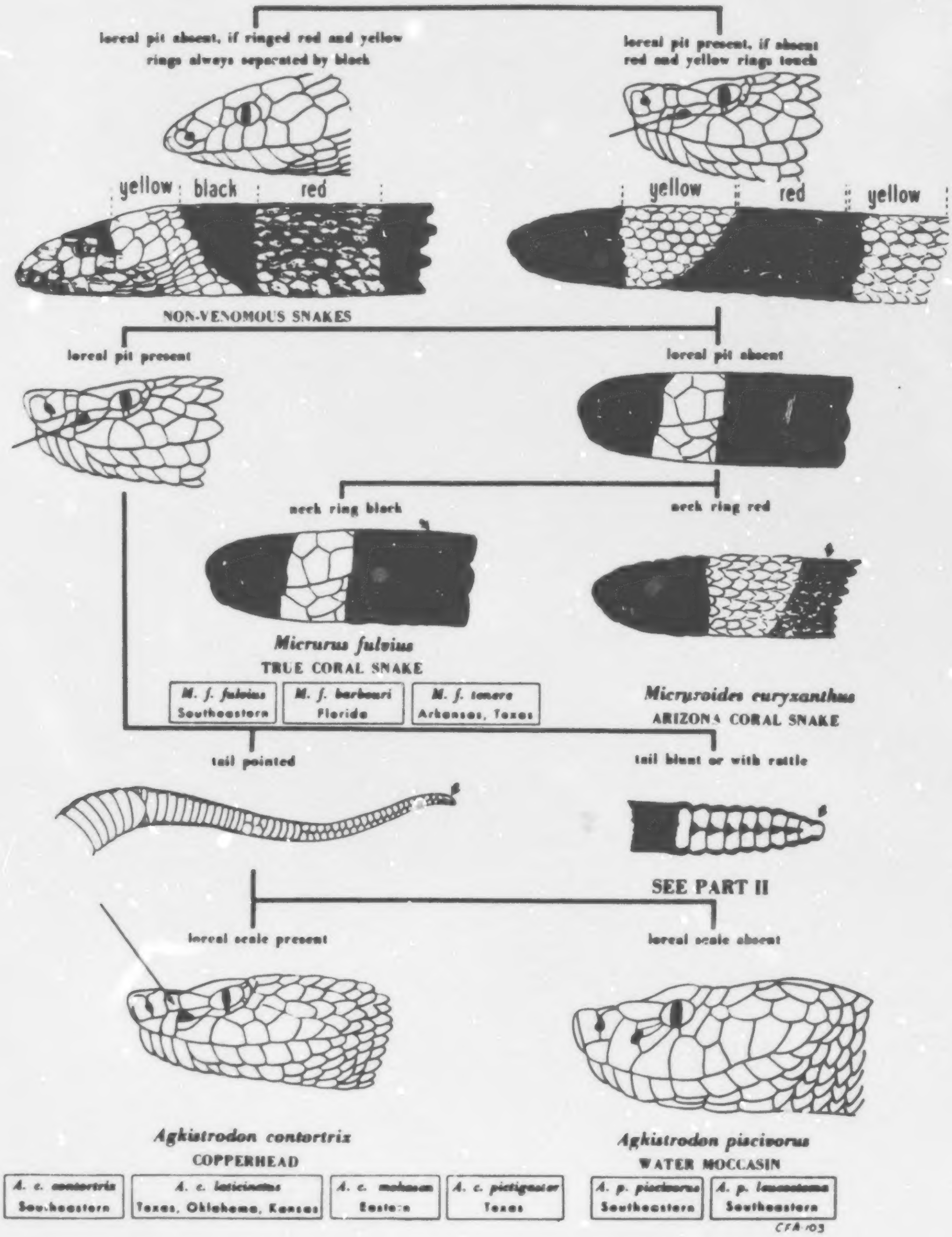
SNAKES: PICTORIAL KEY TO VENOMOUS SPECIES IN UNITED STATES
PART I


loreal pit absent, if ringed red and yellow rings always separated by black
loreal pit present, if absent red and yellow rings touch
yellow
black
red
yellow
red
yellow
NON-VENOMOUS SNAKES
loreal pit present
loreal pit absent
neck ring black
neck ring red
Micrurus fulvius
TRUE CORAL SNAKE
M. f. fulvius
Southeastern
M. f. barbouri
Florida
M. f. tenere
Arkansas, Texas
Micruroides euryxanthus
ARIZONA CORAL SNAKE
tail pointed
tail blunt or with rattle
SEE PART II
loreal scale present
loreal scale absent
Agkistrodon contortrix
COPPERHEAD
A. c. contortrix
Southeastern
A. c. laticinctus
Texas, Oklahoma, Kansas
A. c. mokasen
Eastern
A. c. pictigaster
Texas
Agkistrodon piscivorus
WATER MOCCASIN
A. p. piscivorus
Southeastern
A. p. leucostoma
Southeastern
CFA-103

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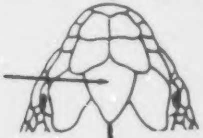
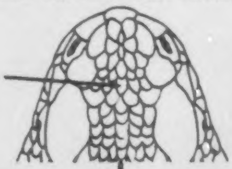
PART II

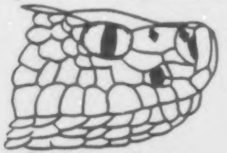
head with large scales medially



head with small scales medially



upper preocular usually touching postnasal

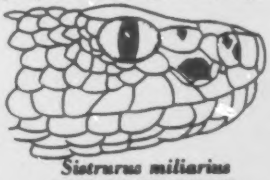


Sistrurus catenatus
MASSASAUGA RATTLESNAKE

S. c. catenatus	*S. c. edwardsii*
Great Lakes & Central U.S.	Arizona, Colorado, New Mexico, Texas

S. c. tergeminus
Colorado, Kansas, Nebraska, New Mexico, Oklahoma, Texas

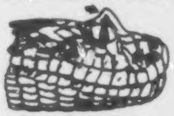
upper preocular and postnasal separated



Sistrurus miliarius
PIGMY RATTLESNAKE

S. m. miliarius	*S. m. barbouri*	*S. m. streckeri*
Southeastern	Southeastern	Southeastern

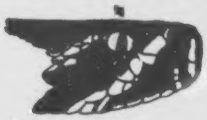
supraocular scale modified into a hornlike ridge



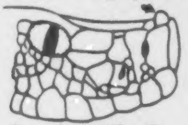
Crotalus cerastes
SIDEWINDER RATTLESNAKE

C. c. cerastes	*C. c. cercobombus*	*C. c. laterorepens*
Arizona, California, Nevada, Utah	Arizona	Arizona, California

supraocular scale not modified into a hornlike ridge



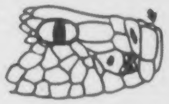
internasal ridge present



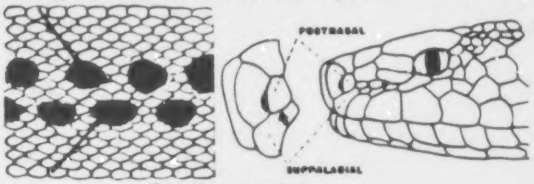
Crotalus willardi
RIDGE-NOSED RATTLESNAKE

C. w. silus	*C. w. willardi*
New Mexico	Arizona,

internasal ridge absent

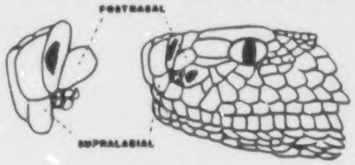


dorsal blotches on body divided into 2 parallel rows
first supralabial scale broadly attached to postnasal scale



Crotalus pricei
TWIN-SPOTTED RATTLESNAKE Arizona

dorsal blotches on body not divided into 2 parallel rows
first supralabial scale not broadly attached to
postnasal scale, sometimes completely separated



SEE PART III

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PART III

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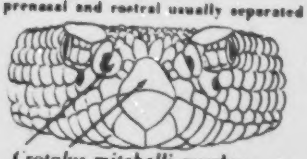
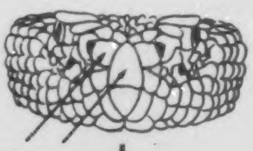
prenasal and rostral usually separated



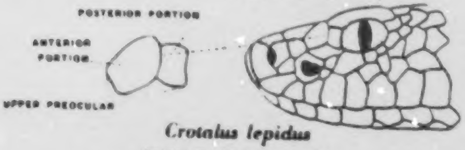
Crotalus mitchelli pyrrhus

SOUTHWESTERN SPECKLED RATTLESNAKE Arizona, California, Nevada, Utah

prenasal and rostral attached



upper preocular usually separated vertically, anterior portion raised above posterior portion

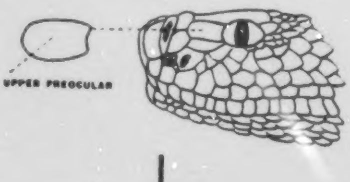


Crotalus lepidus

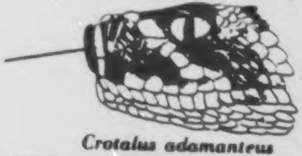
ROCK RATTLESNAKE

C. l. lepidus	*C. l. klauberi*
New Mexico, Texas	Arizona, New Mexico, Texas

upper preocular usually not separated, if separated anterior portion not raised above posterior portion



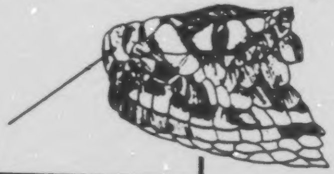
prenasal and supralabial scales with pale stripe



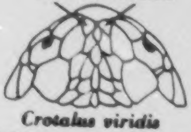
Crotalus adamanteus

EASTERN DIAMONDBACK RATTLESNAKE Southeastern

prenasal and supralabial scales without pale stripe



with 2 internasals



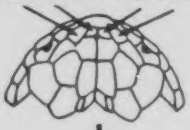
Crotalus viridis

WESTERN RATTLESNAKE

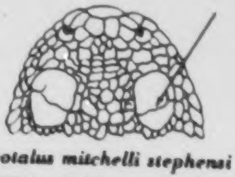
C. v. viridis	*C. v. abyssus*	*C. v. cerberus*	*C. v. concolor*
West Central U.S.	Arizona	Arizona	Colorado, Utah

C. v. helleri	*C. v. lutosus*	*C. v. nuntius*	*C. v. oreganus*
California	Nevada & adjoining states	Arizona	California, Idaho, Oregon, Washington

with more than 2 internasals



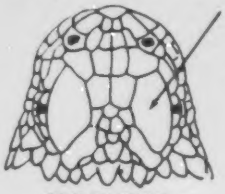
supraocular scale divided, pitted or margins uneven



Crotalus mitchelli stephensi

PANAMINT RATTLESNAKE California, Nevada

supraocular scale not divided, pitted or margins uneven



SEE PART IV

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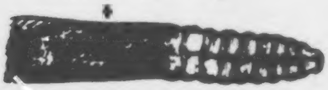
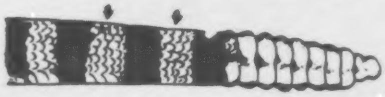
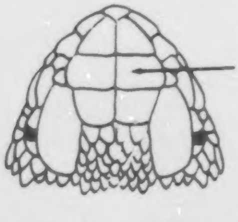
tail without distinct rings



tail with distinct rings



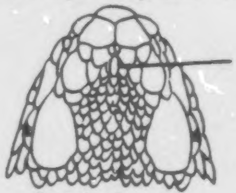
anterior frontal area with large scales



Crotalus molossus

BLACK-TAILED RATTLESNAKE Southwestern

anterior frontal area with scales not much larger than posterior scales

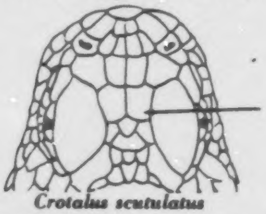


Crotalus horridus

CANEBRAKE OR TIMBER RATTLESNAKE

C. h. horridus Eastern	*C. h. atricaudatus* Southeastern

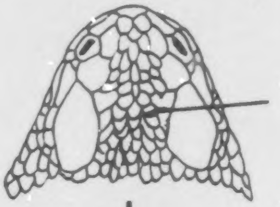
scales between supraoculars usually 2



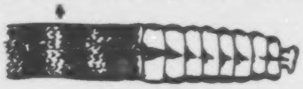
Crotalus scutulatus

MOHAVE RATTLESNAKE Arizona, California, Nevada, New Mexico, Texas

scales between supraoculars usually 4, or more



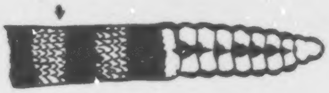
tail not in sharp contrast to posterior part of body



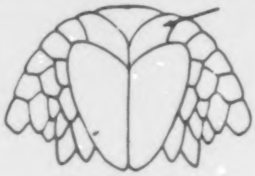
Crotalus tigris

TIGER RATTLESNAKE Arizona

tail in sharp contrast to posterior part of body



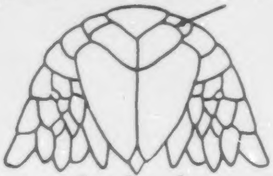
first infralabial scale rarely divided, body color grayish



Crotalus atrox

WESTERN DIAMONDBACK RATTLESNAKE Southwestern

first infralabial scale usually divided, body color pink or red



Crotalus ruber

RED DIAMONDBACK RATTLESNAKE California

CFR-10b

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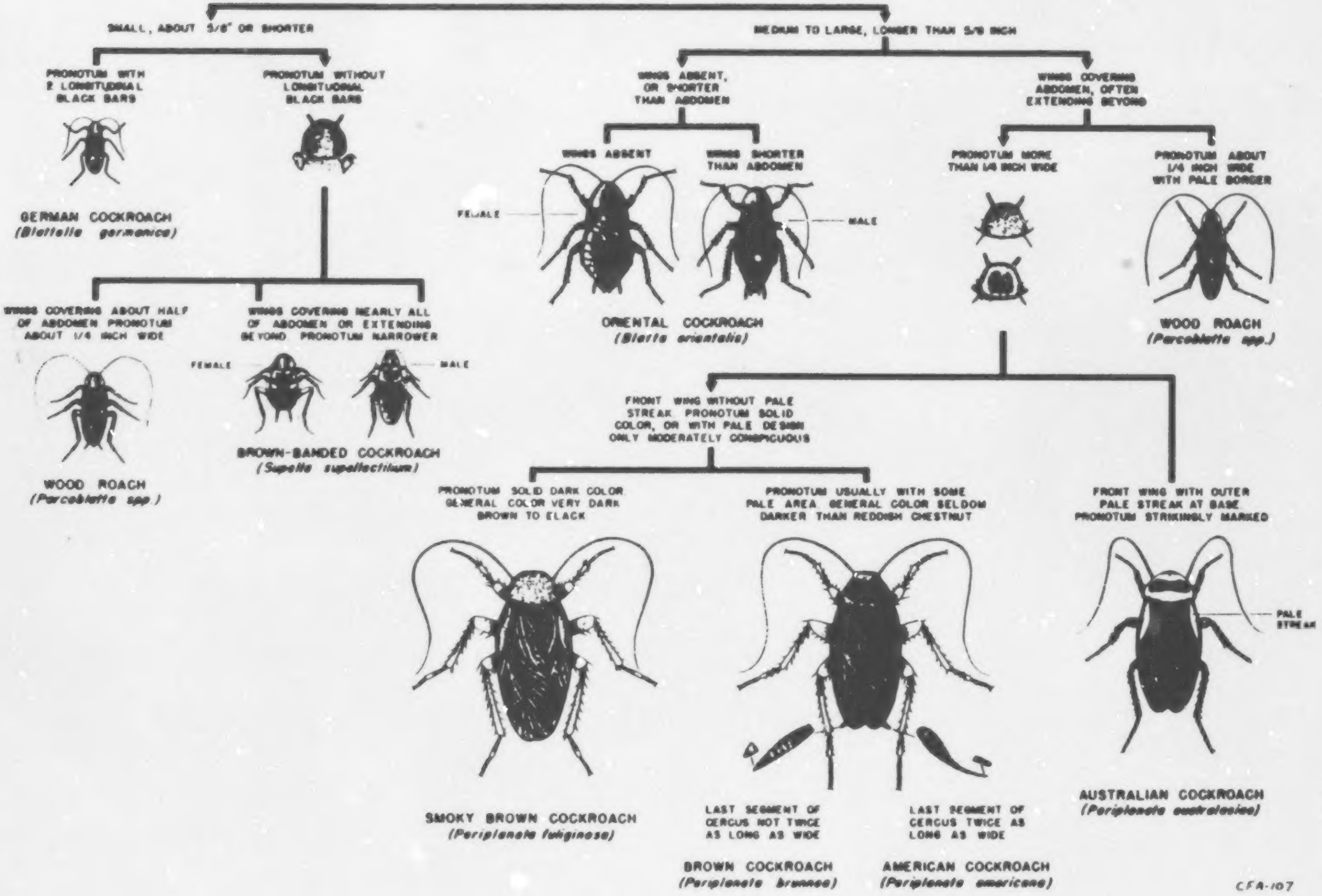
COCKROACHES: PICTORIAL KEY TO SOME COMMON SPECIES


SMALL, ABOUT 5/8" OR SHORTER
MEDIUM TO LARGE, LONGER THAN 5/8 INCH
PRONOTUM WITH 2 LONGITUDINAL BLACK BARS
PRONOTUM WITHOUT LONGITUDINAL BLACK BARS
GERMAN COCKROACH
(Blattella germanica)
WINGS COVERING ABOUT HALF OF ABDOMEN PRONOTUM ABOUT 1/4 INCH WIDE
WINGS COVERING NEARLY ALL OF ABDOMEN OR EXTENDING BEYOND PRONOTUM NARROWER
WOOD ROACH
(Parcoblatta spp.)
FEMALE
MALE
BROWN-BANDED COCKROACH
(Supella supellectilium)
WINGS ABSENT, OR SHORTER THAN ABDOMEN
WINGS COVERING ABDOMEN, OFTEN EXTENDING BEYOND
WINGS ABSENT
WINGS SHORTER THAN ABDOMEN
FEMALE
MALE
ORIENTAL COCKROACH
(Blatta orientalis)
PRONOTUM MORE THAN 1/4 INCH WIDE
PRONOTUM ABOUT 1/4 INCH WIDE WITH PALE BORDER
WOOD ROACH
(Parcoblatta spp.)
FRONT WING WITHOUT PALE STREAK PRONOTUM SOLID COLOR, OR WITH PALE DESIGN ONLY MODERATELY CONSPICUOUS
FRONT WING WITH OUTER PALE STREAK AT BASE PRONOTUM STRIKINGLY MARKED
PRONOTUM SOLID DARK COLOR GENERAL COLOR VERY DARK BROWN TO BLACK
PRONOTUM USUALLY WITH SOME PALE AREA. GENERAL COLOR SELDOM DARKER THAN REDDISH CHESTNUT
PALE STREAK
SMOKY BROWN COCKROACH
(Periplaneta fuliginosa)
LAST SEGMENT OF CERCUS NOT TWICE AS LONG AS WIDE
LAST SEGMENT OF CERCUS TWICE AS LONG AS WIDE
BROWN COCKROACH
(Periplaneta brunnea)
AMERICAN COCKROACH
(Periplaneta americana)
AUSTRALIAN COCKROACH
(Periplaneta australasiae)
CFA-107

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ANTS: KEY TO SOME COMMON SPECIES

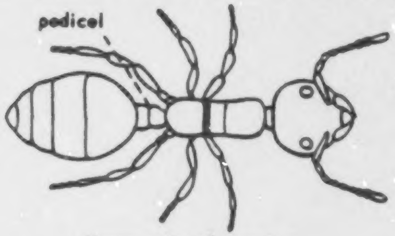
1. Pedicel ("waist") 1-segmented 2
   Pedicel 2-segmented 4

2. Petiole (scale on pedicel) poorly developed, hidden beneath abdomen
   (Tapinoma sessile) . . . . ODOROUS HOUSE ANT
   Petiole well-developed, erect, not hidden beneath abdomen 3

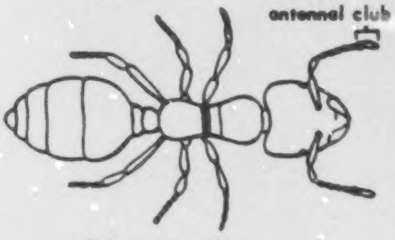
3. Tip of abdomen without circlet of hairs *(Iridomyrmex humilis)* . . . . ARGENTINE ANT
   Tip of abdomen with circlet of hairs *(Camponotus herculeanus*
   pennsylvanicus) . . . . BLACK CARPENTER ANT

4. Head and thorax with numerous spines *(Atta texana)* . . . . TEXAS LEAF-CUTTING ANT
   Head and thorax spineless or with 1 pair of spines on the posterior thorax 5

5. Thorax and head covered with "fingerprints"; posterior thorax with
   single pairs of spines *(Tetramorium caespitum)* . . . . PAVEMENT ANT
   Thorax and head without "fingerprints"; posterior thorax without spines 6



Monomorium pharaonis



Solenopsis molesta

6. Antennal club 2-segmented 8
   Antennal club 3-segmented 7

7. Shiny-black *(Monomorium minimum)* . . . . LITTLE BLACK ANT
   Yellowish-red *(Monomorium pharaonis)* . . . . PHARAOH ANT

8. House infesting ants *(Solenopsis molesta)* . . . . THIEF ANT
   Outdoor mound-building ants 9

9. Mandibles strongly incurved *(Solenopsis geminata)* . . . . TROPICAL FIRE ANT
   Mandibles not strongly incurved 10

10. Dorsal surface of head with large coarse, scattered punctures
    (Solenopsis saevissima var. richteri) . . . . IMPORTED FIRE ANT
    Dorsal surface of head without punctures *(Solenopsis xyloni)* . . . . SOUTHERN FIRE ANT

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MOTHS: KEY TO SOME SPECIES COMMONLY ASSOCIATED WITH STORED FOOD

1. Caterpillars 2
   Adult moths 5

2. Pinkish larvae up to 3/5-inch long living in silken tubes and producing matter webbing in the infested food (*Anagasta kuhniella*) . . . . MEDITERRANEAN FLOUR MOTH
   Whitish larvae with or without black or orange markings 3

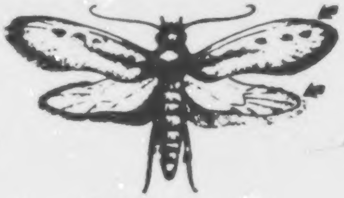
3. Black head and prothorax; orange markings at both ends of the body; living in silken tubes (*Pyralis farinalis*) . . . . MEAL MOTH
   Without black head and prothorax 4

4. White to greenish-white larvae producing matter webbing in the infested food (*Plodia interpunctella*) . . . . INDIAN MEAL MOTH
   Whitish; not producing matted webbing; living inside kernels of grain (*Sitotroga cerealella*) . . . . ANGOUMOIS GRAIN MOTH

5. Wings unicolorous to slightly spotted; long fringe at rear of wings (*Sitotroga cerealella*) . . . . ANGOUMOIS GRAIN MOTH
   Wings heavily dark marked 6

6. Distal half of front wings dark, basal half light (*Plodia interpunctella*) . . . . INDIAN MEAL MOTH
   Wings not so marked 7

7. Basal and distal thirds of front wings dark; middle portion of front wings light (*Pyralis farinalis*) . . . . MEAL MOTH
   Front wings pale gray with transverse wavy black markings (*Anagasta kuhniella*) . . . . MEDITERRANEAN FLOUR MOTH



Angoumois Grain Moth

CF4-109

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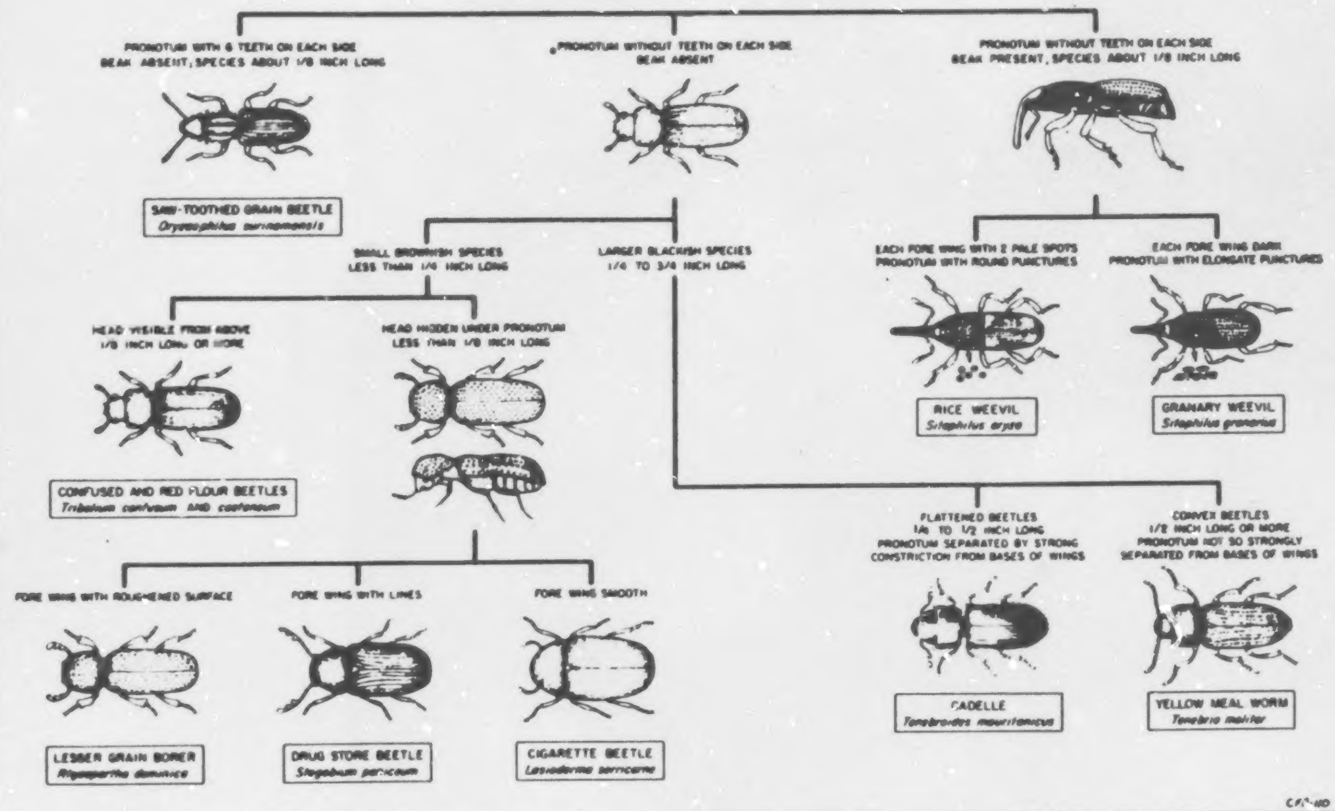
BEETLES: PICTORIAL KEY TO SOME SPECIES COMMONLY ASSOCIATED WITH STORED FOODS


PRONOTUM WITH 6 TEETH ON EACH SIDE
BEAK ABSENT; SPECIES ABOUT 1/8 INCH LONG
SAW-TOOTHED GRAIN BEETLE
Oryzaephilus surinamensis
PRONOTUM WITHOUT TEETH ON EACH SIDE
BEAK ABSENT
PRONOTUM WITHOUT TEETH ON EACH SIDE
BEAK PRESENT, SPECIES ABOUT 1/8 INCH LONG
SMALL BROWNISH SPECIES
LESS THAN 1/4 INCH LONG
LARGER BLACKISH SPECIES
1/4 TO 3/4 INCH LONG
EACH FORE WING WITH 2 PALE SPOTS
PRONOTUM WITH ROUND PUNCTURES
EACH FORE WING DARK
PRONOTUM WITH ELONGATE PUNCTURES
HEAD VISIBLE FROM ABOVE
1/8 INCH LONG OR MORE
HEAD HIDDEN UNDER PRONOTUM
LESS THAN 1/8 INCH LONG
RICE WEEVIL
Sitophilus oryza
GRANARY WEEVIL
Sitophilus granarius
CONFUSED AND RED FLOUR BEETLES
Tribolium confusum AND castaneum
FLATTENED BEETLES
1/4 TO 1/2 INCH LONG
PRONOTUM SEPARATED BY STRONG
CONSTRICTION FROM BASES OF WINGS
CONVEX BEETLES
1/2 INCH LONG OR MORE
PRONOTUM NOT SO STRONGLY
SEPARATED FROM BASES OF WINGS
FORE WING WITH ROUGHENED SURFACE
FORE WING WITH LINES
FORE WING SMOOTH
CADELLE
Tenebroides mauritanicus
YELLOW MEAL WORM
Tenebrio molitor
LESSER GRAIN BORER
Rhyzopertha dominica
DRUG STORE BEETLE
Stegobium paniceum
CIGARETTE BEETLE
Lasioderma serricorne
CFC-HD

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CONTENTS

Appendix C

Page	*Key*
C-1	Integrated Pest Management Methods
C-2	(Continued)
C-3	(Continued)
C-4	(Continued)
C-5	(Continued)

INTEGRATED PEST MANAGEMENT METHODS*

PEST	CULTURAL	MECHANICAL	PHYSICAL (PHYSIOLOGICAL)	BIOLOGICAL	GENETIC	CHEMICAL	REGULATORY
1. Cockroaches	● Design (Preventive) ● Design out harborage and allow access for chemical treatment ● Sanitation ● Good Housekeeping ● Cockroach proof containers	● Harborage elimination (corrective) ● Caulking ● Remove unused equipment ● Trapping (limited control)	● Cold storage ● Moisture control	● Parasitic wasp on American cockroach (Hawaii) (Texas) ● Parasitic wasp on brownbanded cockroach (Hawaii, California)	● Sterilization (experimental)	● Repellents Insecticides ● Baits ● Residual ● liquids ● Non-Residual (ULV) ● Fumigants ● CO_2 (Hospital Carts	● P-352 (CH.) Pest Control in Navy Family Housing ● Activity Instructions on sanitation standards and inspections ● NAVMED P-5010 (CH. 1,2)
2. Rats/Mice	● Landfill Location ● Sanitation ● Food source removal ● Water source removal ● Food storage/packaging practices (rodent proof con-	● Rodent Proofing ● Harborage elimination ● Trapping Snap Trap Live Trap Sticky Trap Nest removal	● Sonic and electromagnetic devices not effective		● Antiovulant (Experimental)	● Rodenticides ● Anticoagulant baits ● Single dose baits ● Tracking powders ● Burrow fumigation	● Local laws and activity instructions on landfill operations ● OPNAVINST 4565.1 Retrograde Cargo ● SECNAVINST 6210.2 Quarantine Regulations
3. Ants	● Sanitation ● Good Housekeeping ● Vegetation Removal	● Ant Proofing ● Sealing cracks ● Vacuuming Barrier (water) (petroleum jelly, stickum)	● Soak houseplant pots to drown			● Insecticides Baits Residual liquids	● Federal and state quarantine (fire ants)
4. Mosquitoes	● Water Management ● Ditch ● Drain ● Fill ● Flood ● Vegetation Control ● Aquatic plants ● Mowing to reduce resting sites ● Plant selection (water trappers)	● Screening ● Remove trash providing breeding site	● Sonic devices not effective	● Predatory fish ● Nematodes ● Fungi ● Bacteria ● Predatory mosquito (Toxorchychites sp.) Purple martins not effective	● Sterlization (A. albimanus) only	● Repellents (personal) ● Larvicides ● Insect growth regulators ● Biodegradable oils ● Residuals ● Controlled release ● Liquids ● Adulticides ● Non-Residual (aerosols) ● Residual (ULV) ● Barrier treatments	● Coordination with local mosquito abatement districts ● Quarrantine - Public Health
5. Filthflies	● Sanitation ● Breeding source reduction ● Steam clean dumpsters	● Screening ● Air curtains ● Trapping ● Fly paper ● Attractant (Muscalure) ● Fly swatter ● Electric fly grid		● Parasitic wasp (Spalangia sp.)	● Sterilization (Experimental)	● Insecticides ● Baits ● Non-Residual (aerosols) (ULV) ● Residuals	● Activity instructions on sanitation standards and inspections

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INTEGRATED PEST MANAGEMENT METHODS*

PEST	CULTURAL	MECHANICAL	PHYSICAL (PHYSIOLOGICAL)	BIOLOGICAL	GENETIC	CHEMICAL	REGULATORY
6. Biting Flies	● Sanitation (Stable Fly) ● Breeding source reduction ● Manure ● Grass Clippings ● Seaweed ● Water management (culicoides, black fly, deerfly) ● Soil management ● Schedule activities to reduce exposure ● Aquatic weed emergent) management	● Screening ● Trapping ● Sticky Trap Live Trap		● Parasitic wasp (*Spalangia sp.*)	● Sterilization (Stable Fly)	● Repellents (personal) ● Insecticides ● Non-Residuals (aero- ● Residuals	● Activity instructions on stable operations (Stable Flies) ● Quarantine Public Health
7. Wasps, Hornets, Bees	● Sanitation ● Food source removal ● Turf management ● Clover removal ● Diversion ● Grow nectar and pollen sources in infrequented sites	● Nest removal ● Swarm removal (Honey Bees) ● Trapping ● Screening				● Freezing agent aerosols/ CO_2 dispenser ● Repellents ● Insecticides ● Non-Residual aerosols ● Residuals ● Baits	● Quarantine USDA, others
8. Subterranean Termites	● Design (Preventive) ● Sanitation (preconstruction clearing of all wood material) ● Termite shields for survey	● Repair and maintenance (corrective) ● Moisture control/water drainage ● Removal of wood scraps ● Screening		● Bait with symbiont-killing antibiotics		● Wood preservatives ● Insecticides ● Soil treatment with residuals ● Bait blocks ● Repellents	● Quarantines ● Activity instructions requiring annual inspections
9. Non-Selective Weed Control	● Selective planting ● Cultivation ● Burning	● Barriers ● Plastic ● Gravel ● Pavement ● Hand removal				● Growth regulators ● Herbicides ● Selective ● Non-Selective ● Short-term ● Long-term	● State regulations on weeds
10. Spiders	● Sanitation ● Harborage removal (debris) ● Prey insect control	● Removal of webs, adults, eggs (vacuum) ● Spider proofing ● Screen ● Sealing cracks		● Wasps		● Freezing agent aerosols ● Insecticides ● Non-Residual aerosols ● Residual	

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INTEGRATED PEST MANAGEMENT METHODS*

PEST	CULTURAL	MECHANICAL	PHYSICAL (PHYSIOLOGICAL)	BIOLOGICAL	GENETIC	CHEMICAL	REGULATORY
11. Stored Products Pest (Insect)	● Sanitation ● Acceptance inspection ● Good housekeeping ● Selection of synthetic materials	● Insect proof packaging/storage ● Short storage time ● Sieving ● Disposal/survey (Last Resort) ● Isolation of infested stores	● Cold storage ● Dry cleaning ● Dehumidification			● Repellents (packaging) ● Insecticides ● Non-Residual (ULV) ● Residual ● Fumigation	● Quarantine ● In transit fumigation requirements
12. Fleas	● Sanitation ● Good housekeeping ● Management of domestic host animals ● Control of feral host animals	● Vacuuming ● Remove carpets in public areas				● Insecticides ● Non-Residual aerosols ● Residuals ● Flea collars	● Quarantine (Derat Certificate)
13. Vertebrate Pest and Other Rodents	● Sanitation ● Food source removal ● Water management (aquatic vertebrates) ● Habitat manipulation	● Harborage elimination ● Pest proofing ● Barriers ● Trapping ● Live ● Lethal ● Shooting ● Animal removal	● Low temperature [illegible]			● Repellents ● Pesticides ● Anticoagulant baits ● Single dose baits ● Fumigation ● Birth control hormones	● Federal and state permits ● Activity instructions on pet control
14. Insect pests of vegetation	● Resistant plant varieties ● Plant care	● Removal ● Hand picking ● Water sprays ● Soap sprays	● Many systems available based on pest species			● Pesticides ● Residual contract and and systemics	● Quarantine
15. Ticks/Mites	● Weed and brush Control ● Management of domestic host animals ● Control of feral host animals	● Hand removal Vacuuming				● Repellents (personal) ● Pesticides ● Residual ● Systemics for animals	● Activity instructions on tick exposure and removal

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INTEGRATED PEST MANAGEMENT METHODS*

PEST	CULTURAL	MECHANICAL	PHYSICAL (PHYSIOLOGICAL)	BIOLOGICAL	GENETIC	CHEMICAL	REGULATORY
16. Birds	● Design ● Sanitation ● Food source removal ● Landfill location ● Sewage lagoon location	● Bird Proofing ● Nest removal ● Trapping ● Shooting ● Mist Nets ● Scare devices	● Habit interruption ● Distress calls ● Light and sound emitters not effective ● Exposure to cold (tergitol) ● Simulated Predator Kites (England)	● Predators	● Sterilization (Ornitrol-Pigeons)	● Repellents ● Avicides ● Baits ● Residual liquids and greases)	● Federal and state permits
17. Selective Weed Control (Grasses/Broad Leaf Weeds/ Brush)	● Selective planting ● Mulching ● Cultivation ● Fertilization ● Grazing ● Watering practices	● Removal/clearing ● Mowing ● Cutting ● Pruning ● Barriers		● Insects on Lantana, musk thistle (exp)		● Growth regulators ● Fruiting inhibition ● Herbicides ● Selectives ● Pine release ● Prilling ● Stump injection	● Quarantine
18. Household Pest (Silverfish, Psocids, crickets, Bedbugs)	● Sanitation ● Good Housekeeping ● Control of feral host animals (bedbugs)	● Pest proofing (crickets) ● Harborage elimination ● Vacuuming ● Sanitizing/ laundering ● Trapping Sticky Trap	● Temperature control ● Humidity			● Repellents ● Insecticides ● Baits ● Non-Residual aerosols ● Residual liquids	
19. Aquatic Weeds	● Pond and ditch design ● Water management ● Level ● Flow ● Quality (Nutrients)	● Removal ● Barriers ● Mowing ● Cutting		● Fish (White Amur) (highly restricted) ● Insect ● Alligator - Weed Beetle ● Moth (Alligator-Weed) ● Weevil		● Herbicides	● Quarantine

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INTEGRATED PEST MANAGEMENT METHODS*

PEST	CULTURAL	MECHANICAL	PHYSICAL (PHYSIOLOGICAL)	BIOLOGICAL	GENETIC	CHEMICAL	REGULATORY
20. Wood Destroying Insects (Drywood Termites, Beetles, Carpenter Ants	● Design ● Selection of resistant lumber/materials	● Repair/maintenance	● Exposure to high or low temperature (dry-termites)			● Wood preservatives ● Insecticides ● Residual ● Fumigation	● Quarantine ● Activity instruction requiring annual inspection
21. Wood Destroying Fungi	● Design ● Proper storage of wood ● Vegetation management ● Selection of resistant lumber	● Repair/maintenance	● Ventilation ● Moisture control, drainage, vapor barriers in crawl spaces ● Protect stored lumber			● Wood preservatives ● Pressure treatment ● Brush treatment ● Dip treatment	● Activity instruction requiring annual inspections ● Quality assurance inspections ● Require storage protection and pressure treated materials

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* Information obtained form a variety of reference material including MO-310, EPA and various state training and certification manuals and NPCA technical releases.

+ Pest or pest groups are ordered according to frequency data obtained from DD Form 1332 submittals for FY 1976.

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NOTE: In this volume, the subject matter is developed by a series of Learning Objectives. Each of these carries a 3-digit number and is in boldface type. Each sets a learning goal for you. The text that follows the objective gives you the information you need to reach that goal. The exercises following the information give you a check on your achievement. When you complete them, see if your answers match those in the back of this volume. If your response to an exercise is incorrect, review the objective and its text.

Introduction to Entomology

MAN HAS BEEN in contact with different types of insects and pests during his entire existence. These insects and pests exceed 2,000,000 known species, and scientists are constantly discovering new ones during their scientific studies and explorations. The results of these studies and explorations indicate that when all insects are known, their number will exceed 7,000,000 species.

Today, as we frequently come in contact with insects, most of us look upon them as pests, but not as either harmful or beneficial to us. We seldom stop to consider the many insect-borne diseases or the many insect-produced products on the market. Do you know that honey, silk, lacquer, and many other commercial products come from insects? You may not like the thought, but some insects are edible. In contrast, many species of insects, rodents, and related pests seriously affect man. They affect military operations by spreading disease, reducing efficiency of personnel, or destroying property.

One might ask, "How does mankind know so much about insects?" Well, insects have pestered humans so long that ~~they~~ humans were forced to study ~~their~~ insect habits to find ways to control them. The knowledge thus gained soon became a factor in mankind's fight for health and survival. To adequately control an insect, mankind needs to know its characteristics and breeding habits. So began the study which is known as entomology.

Entomology is the science that deals with insects, which make up the majority of our economic pests. These insects and pests are of many species and varieties and live practically everywhere except on the open sea. They live and breed in most of the materials used by man: soil, water, and air. The factors determining their survival are the variations of climate and the lack or surplus of food, water, and shelter; however, many insects can adapt amazingly to changes in environment.

The science of entomology is divided into two major categories: *economic* and *medical*. The economic category has been subdivided into five branches, which group insects according to their destructive activities. The medical category (to be discussed later) establishes the insect-borne diseases and the insects responsible for them.

For the present, these are the five major groups of the economic category:

a. Agricultural. The agricultural branch deals with the growing of field and truck crops. This area includes many types of insecticides which cause death to insects from eating, direct contact, or breathing.

b. Horticultural. This branch deals with the wooded plants which are attacked by insects.

c. Veterinary. Veterinary entomology is closely associated with medical entomology and deals with the control of insects that attack domestic animals. This branch is divided into two areas. One area deals with insects that infest the animal internally, and the other deals with those that bite, sting, or otherwise irritate the animal.

d. Stored product pests. This field is concerned with the control of insects that attack foodstuffs, and the method by which the food may be guarded and the insects eradicated.

e. Household pests. These pests are the same as the stored product group and can be controlled by the same methods.

In addition to entomological functions, you will be concerned with activities pertaining to botany (the science of plants) and zoology (the science that deals with animals). Therefore, this CDC will provide you with an understanding of the fundamental principles and procedures involved in the identification, control, and eradication of arthropod, vertebrate, and vegetative pests. In this chapter we discuss systematic biology, the Animal Kingdom, orders of common insects, and the arthropods.

Remember, you will be working with apprentice pest managers, and other specialists and technicians to accomplish the functions mentioned above. The procedures used for a job to be done are established by the civil engineer or your supervisor as we have already discussed.

1-1. Arthropod Taxonomy

It is impossible to determine the scientific name of an insect without the aid of an orderly arrangement or classification of species.

This section deals with the procedures in which the naming of living organisms occurred. The word "taxonomy" is defined simply as the science of classification.

As pest managers we must have a knowledge of the system used in naming or classifying living organisms and the method used in writing and recognizing these names, and recognition. Believe it or not, at one time there was no recognized standard system of classification. Imagine how confusing this must have been, having no recognizable name.

200. Define and state the purpose of systematic biology.

Systematic Biology. Systematic biology is the arrangement of living things into groups having similar characteristics. Our discussion here should help you understand (1) the beginning of systematic biology, (2) the binomial system of nomenclature, and (3) the Animal Kingdom.

Even from the early beginning, people have attempted to harness nature and its resources, but found that it was only through the knowledge of things (animal and plant) that people could satisfy their needs and subsist in their environment. People also learned that once the identity of a living thing (plant or animal) was established, they could further describe it, learn more about it, and use this knowledge to obtain their own ends. Animals needed standardized and universally accepted names so people would know which animal they were talking about. The identity of the animal became the key to all knowledge pertaining to it.

Because of the large numbers of living things, people discovered it was impossible to identify them without an orderly system of classification; therefore, the systematic biology system of identification and arrangement began.

In 350 BC, Aristotle, a Greek philospher, suggested a classification of plants and animals. This was accepted throughout the Middle Ages. In the first attempts to describe and relate living animals, only generalized body structures and habits were considered. With increased knowledge and the rapid discovery of new species, a better system of classification was evolved—the binomial system of nomenclature.

Exercises (200):

1. Systematic biology is defined as ____________ ____________________________.
2. The system which provides an orderly system of classification is known as ____________.
3. Systematic biology was established to provide ____________ and ____________ accepted names.

201. Define the binomial system of nomenclature and identify the genus and specie in examples provided.

Binomial System of Nomenclature. The binomial system of nomenclature was proposed by Carl Vonlinne, a Swedish naturalist, in 1758 when he published the first extensive and practical book on animal nomenclature. It was a systematic means of applying two names to an organism and became the foundation of modern systematic biology. This publication named and described 4379 species of animals. Our present system of nomenclature is based on the 10th edition of this publication, and all scientific names listed have been accepted to the present day.

Now that you know the term "binomial system of nomenclature" means applying two names to an organism, you must know what two names are used, the method by which it is written, and how it can be recognized in other publications, remembering that this is a standard procedure and is universally recognized. The two words used, *genus* and *specie* (which we will discuss later in this section), constitute a scientific name. When the scientific name is written, the first name refers to the genus and always begins with a capital letter. The second name refers to the specie and begins with a small letter. The genus usually is the noun and the specie is the adjective, which is a common occurrence in Latin. The scientific name can be recognized in publications by being printed in italics, with the first letter of the genus being capitalized and the first letter of the specie being a small letter. When the scientific name is written without being italicized, both names are underlined along with the first letter of the genus being capitalized and the first letter of the specie being a small letter, so as to appear in this manner: Anopheles quadrimaculatus.

Although it is very important to know what constitutes a scientific name and how to recognize it, this course deals primarily with common names.

A common name is a name in English of an undefined number of words, usually descriptive of the animal's structure, coloration, or habits. Common American arthropod pests have been assigned standardized names by the American Association of Economic Entomologists; these names are published by this organization for interested persons.

NOTE: Most arthropod pests and vector studies in this CDC have correct and standardized common names. Only in a few cases will you be responsible for their scientific name, for example, *Anopheles, Culex,* etc. Colloquial names (those used in certain areas of the country) are actually considered unsuitable in systematic biology and (if seen in this volume) are included only to identify types of insects that you have seen before. These colloquial names, if used, will be enclosed in quotes ("popping bugs," "daddy long-legs," "devil horses," etc.).

Exercises (201):

1. Define binomial system of nomenclature.

2. Identify the genus in the following example by circling the appropriate word. *Pulex irritans*

3. Identify the specie in the following example by circling the appropriate word. *Musca domestica*

4. Combining the two names, genus and specie constitute a ______________________________ .

202. Identify the classification nomenclature divisions of the Animal Kingdom.

Classification Nomenclature Divisions. All living things are classified according to their sexually mature structure and are divided into the Plant and Animal *Kingdoms;* however, there are some living things (viruses, rickettsiae, and spirochaetes) which cannot be assigned definitely to either kingdom and are recognized as the Undefined Kingdom. The Animal Kingdom is made up of a number of major divisions, or *PHYLA* (singular, *PHYLUM).* The Phylum Chordata contains all the animals with a backbone, including humans and other mammals, birds, reptiles, and fish. The Phylum Arthropoda contains about 86 percent of all described animal species. Members of this phylum have segmented bodies, jointed appendages, and an exoskeleton. The arthropods are divided into *CLASSES* including Class ~~Insecta~~ Hexapoda - insects; Class Arachnida - ticks, mites, spiders, scorpions, and others; Class Crustacea - crabs, shrimp, copeods, and others; Class Chilopoda - centipedes; and Class Diplopoda - millipedes. Each class is comprised of a number of major groupings called ORDERS, such as the Order Diptera, or true flies. Each order is made up of FAMILIES, such as the Family Culicidae, or mosquitoes. Each family is comprised of one or more *GENERA*, such as the genus *Culex*, and each genus has one or more *SPECIES*, such as *pipiens*, the house mosquito, which has several *SUBSPECIES*, such as *Culex pipiens pipiens*, the northern house mosquito.

Understanding the classification nomenclature divisions may be simplified by comparing them to a pyramid, because beginning at the top there are only a few divisions, and as you descend the scale the divisions get much broader. The following paragraphs will reiterate the classification nomenclature divisions of the Animal Kingdom beginning at the top.

The Animal Kingdom. The Animal Kingdom is divided into universally recognized groups of closely related animals. One group is shown in figure 1-1. This kingdom is one of three basic groups of natural objects that comprise all living and extinct animals. The Animal Kingdom contains several Phyla.

Phylum. Phylum is the first major taxonomic unit comprised of organisms sharing a fundamental pattern of organization and presumably a common descent. This is the largest group of animals and contains many classes.

Class. There are many classes involved in a single phylum, and within each class there are many orders.

Order. Classes are divided into major groups identified as orders. Living things which have common major characteristics are placed into a specific order. Features which are generally used for placement into a specific order are presence or absence of wings, number of wings, type of wings, type of mouthparts, and type of metamorphosis. This will be discussed in more detail later within the section titled "Arthropod Morphology."

Family. Family is still a further breakdown in the classification nomenclature division of the Animal Kingdom. Within each order there may be numerous family groups of which there will be basic similar characteristics which place it in a particular family. Family names can most often be recognized and distinguished from other divisions by the word ending with "idae."

Genus. Genus is the next step in classification, and at this point identification is almost complete. Familiarization with this nomenclature division is very essential to the entomologist in order to identify a specific organism.

Specie. Specie is the last major division within the classification nomenclature. This final (in most cases) identification process is most important since habits and habitats of various species of the same genus may vary greatly, thus affecting the type of control measure you wish to use. This is a distinct group of animals that have well-defined characteristics in common with each other and are capable of producing offsprings with the same characteristics.

Subspecie. When individual species vary from their normal form in structure, coloration, habits, etc., they are often referred to as *subspecie, strain,* or *race*.

Exercises (202):

1. The first step in classification consists of placing an organism into the proper ____________ .
2. A group that is comprised entirely of orders within the classification division is identified as ____________ .
3. The group that is comprised entirely of species is identified as ____________ .

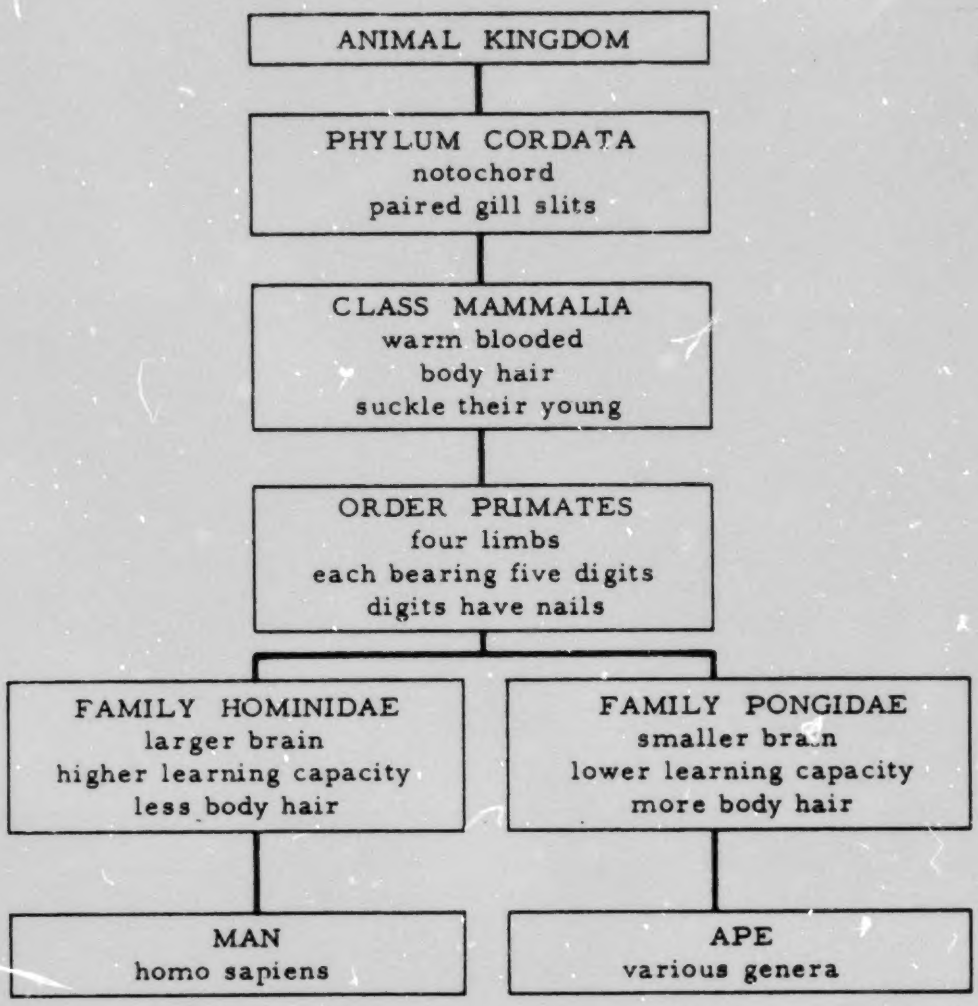
ANIMAL KINGDOM
PHYLUM CORDATA
notochord
paired gill slits
CLASS MAMMALIA
warm blooded
body hair
suckle their young
ORDER PRIMATES
four limbs
each bearing five digits
digits have nails
FAMILY HOMINIDAE
larger brain
higher learning capacity
less body hair
FAMILY PONGIDAE
smaller brain
lower learning capacity
more body hair
MAN
homo sapiens
APE
various genera

Figure 1-1. Animal relationship—man and ape.

4. The term "Arthropoda" would be contained in the ____________ group.
5. The group that immediately precedes and succeeds the group that contains classes is ____________ (preceding) and ____________ (succeeding).
6. The factor that has the most bearing on how all living things are classified is ____________ .

1-2. Arthropod Morphology

Morphology is a branch of biology that deals with the form and structure of animals and plants. Morphology defined is a study of the forms, relations, metamorphosis, and phylogenetic development of organs apart from their functions.

This section will enable you to understand more fully the principles discussed in the previous section on taxonomy and will identify characteristics that place an organism into a particular group. We will be primarily concerned with the Animal Kingdom; especially the Phylum Arthropoda, because the greatest majority of pests that we are concerned with are within this group.

203. Differentiate between the physical structures of the Phylum Arthropoda and the Phylum Chordata.

Comparison of the Physical Structure of Higher Animals and the Insects. Everyone knows that we as humans are different from insects, and we also know that we are classified as the highest animal form, but many do not know what constitutes the difference in the physical structure. Like it or not, insects are placed in the same kingdom as we are (Animal Kingdom), but at this point there are many differences; thus, a separation begins within the classification system. Table 1-1 illustrates the divisions by comparison of man and mosquito, which is an insect. Both

TABLE 1-1
THE CLASSIFICATION SYSTEM FOR A MOSQUITO AND MAN

Name of Category	Mosquito	Man
KINGDOM	ANIMAL--capable of motion; no chlorophyll.	ANIMAL--capable of motion; no chlorophyll.
PHYLUM	ARTHROPODA--jointed appendages; exoskeleton; dorsal heart; ventral nerve cord; cold blood.	CHORDATA--jointed appendages; endoskeleton; ventral heart; dorsal nerve cord
CLASS	Hexapoda ~~INSECTA~~--three pairs of legs; one pair of antennae; wings usually present.	MAMMALIA--mammary glands for suckling young; hair; four-chambered heart; warm blood.
ORDER	DIPTERA--two wings; second pair of wings modified into halters or balancers; sucking mouthparts; complete metamorphosis.	PRIMATES--Limbs elongate, "hands" and "feet" enlarged, often with a thumb, each of five digits with flattened or cupped nails.
FAMILY (Note family names end in idae in zoology)	Culicidae--The true mosquitoes. Adult with scales on wings, elongate proboscis, wings usually longer than abdomen	Hominidae--The family of man.
GENUS	Culex (Latin for mosquito) (note that the generic name of any animal is capitalized and written in italics)	Homo (Latin for man)
SPECIES	pipiens (note that the species name is always written in small letters and in italics) This species name refers to the piping or whining sound of the flying mosquito.	sapiens (Latin for learned)
SUBSPECIES	fatigans	sapiens
AUTHORITY	Wiedemann, 1828	Linnaeus, 1758

man and mosquito are classified as animal because both are capable of motion and neither has chlorophyll, which is a prerequisite for placement in the Animal Kingdom. Using the binomial system of nomenclature, man is identified as *Homo sapiens* (which is Latin for learned man). Looking at table 1-1, the mosquito discussed is scientifically named *Culex pipiens* (which is Latin for whining mosquito). Notice the characteristics which lead to the final classification. In each case, both are classified according to a specific characteristic using Latin words for these characteristics. In almost every case, Latin words are used in the scientific naming process.

Man and insect, as you have already seen, are within the same kingdom; but from this point on, there are many differences, and the further we move down the classification system the broader the differences become. Phylum is the next step in the classification system that must be discussed. The mosquito is classified in the Phylum Arthropoda because it has jointed appendages and an exoskeleton (skeleton on outside). Man is placed in the Phylum Chordata which have jointed appendages and endoskeletons (skeleton on inside). Even though man and mosquito are in different Phyla, they are still closely related, with exception to the type of skeleton system each possesses (comparison shown in fig. 1-2). Class is the next major division of the classification system, and here the mosquito is placed in the Class ~~Insecta~~ Hexapoda. This class includes all animals that have three body regions, three pairs of walking legs, one pair of antennae, and usually wings. The class in which man is included is Mammalia, which means that man must have mammary glands and hair; of course, there are other qualifications that must be met, such as having a four-chambered heart and warm blood. But remember, we are only concerned with the physical structure in this section. The order is the last comparison that we will make between the mosquito and man, because the basic differences should be fully realized and understood before continuance of the breakdown.

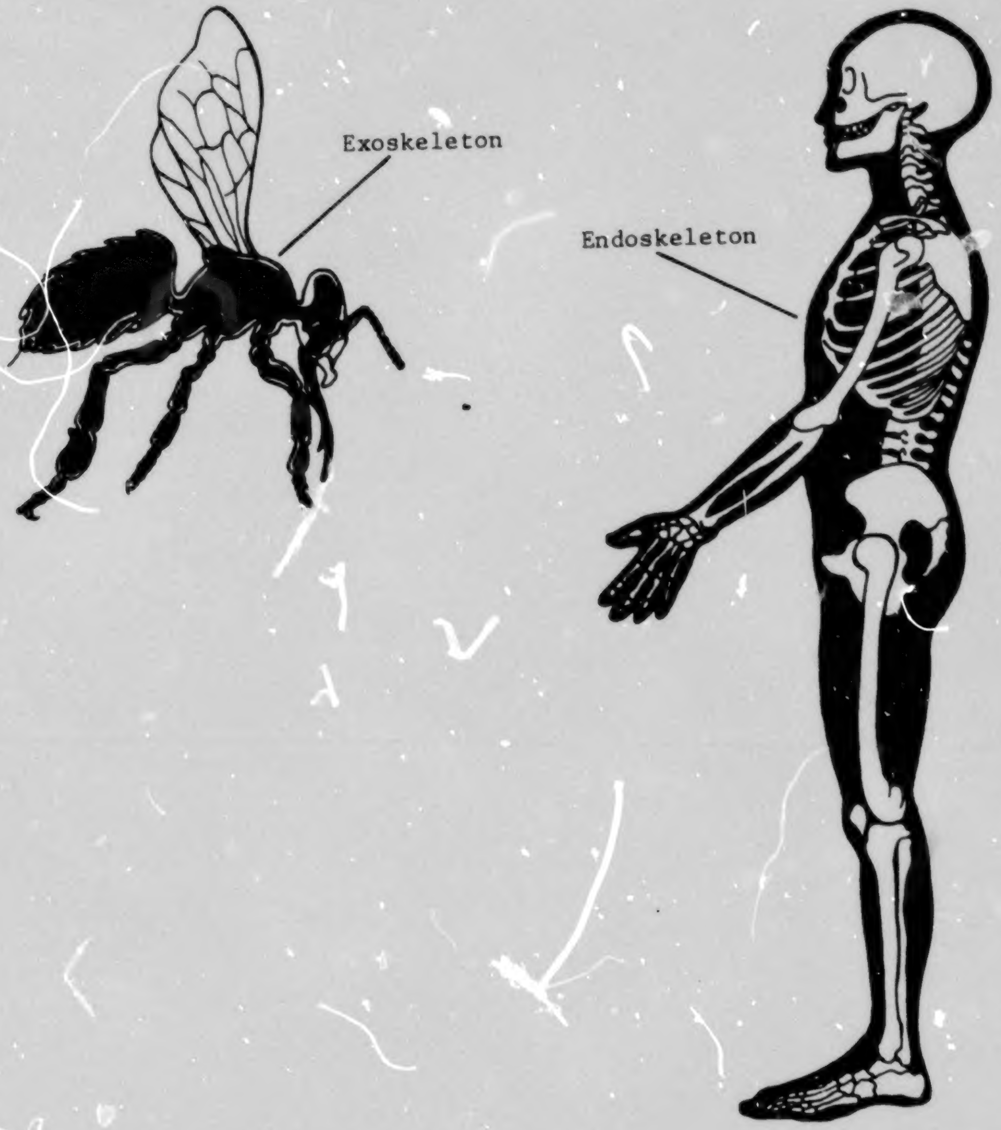

Figure 1-2. Exoskeleton and endoskeleton.

The mosquito is classified as Diptera. The Order Diptera means having two wings with a second pair of wings modified into halteres or balancers, sucking mouthparts, and complete metamorphosis (development process).

Man comes under the Order of Primates because they have long limbs, enlarged hands and feet, often have thumbs, and each of the five digits has flattened or cupped nails.

Exercises (293):

1. Using table 1-1, complete the following statements:
   a. The classification nomenclature division for which both man and mosquito is the same is ____________.
   b. ____________ is the separating classification division of man and mosquito.

2. Complete the following statements:
   a. The prerequisites for an organism to be classified as an animal is that it must be ____________.
   b. The primary difference in the physical structures of the Phylum Arthropoda and Chordata is that the Phylum Arthropoda have ____________.

294. Match the arthropod classes with the appropriate class identification and select the correct response for statements concerning classes of arthropods.

Phylum Arthropoda. An arthropod, as you have already found, is an animal that possesses jointed appendages and an exoskeleton. In addition to these characteristics, an arthropod also has a segmented body, meaning his body is divided into two or more sections. The arthropods outnumber all other groups of animals. Included in this group are crayfish, sow bugs, horseshoe crabs, scorpions, spiders, ticks, mites, centipedes, insects, etc. Arthropods can be found everywhere, and it is possible for them to live in water, on ground, in the ground, or in the air. From the standpoint of human suffering and economic loss, the Phylum Arthropoda presents the most concern to man.

In classification of arthropods the varied structures are grouped into classes. This phylum is generally divided into five classes: Crustacea, Chilopoda, Diplopoda, Arachnida, and ~~Insecta~~ Hexapoda. In many cases arthropods are beneficial to man by providing food and materials; however, many compete with man for food, destroy lawns, shrubbery, homes, and transmit diseases. Throughout this course you will be concerned primarily with the Class ~~Insecta~~ Hexapoda and Arachnida; the remaining classes, Chilopoda, Diplopoda, and Crustacea, are less important.

In the next few paragraphs you will be looking at and studying the physical structures of the various classes of arthropods. We will explain the characteristics of each to enable you to understand the basis for placing an organism in a particular class.

The Class Arachnida (scorpions, spiders, ticks, and mites). The arachnids are common wherever insects occur and are often mistaken for insects. They may be distinguished easily by the fact that they have no antennae and bear four pairs of walking legs in their adult stages. Figure 1-3 illustrates the fact that the first two body regions (head and thorax) are fused to form a cephalothorax. Some arachnids, such as mites and ticks, have only one body division. They breathe by means of booklungs, or tubular tracheae, or by both types of respiratory systems. Their reproductive organs open near the front of the abdomen.

This class ranges in size from microscopic (mites) to 3 or 4 inches (scorpions and spiders). Its habits are highly variable; there are aquatic and terrestrial, parasitic, predaceous, and vegetarian forms. Some are highly active and some remain in one place throughout life. Some produce living young (scorpions) and some lay eggs (ticks, mites, and spiders). With most arachnids, the young resemble the adults. The Class Arachnida is the second most important class of this phylum to humans. It contains serious human disease vectors (ticks and mites) and venomous species (scorpions and the black widow spider). Many varieties are parasitic on birds, animals, and humans (ticks). Many are predaceous or harmful and destructive insects (scorpions and spiders).

The Class Chilopoda (centipedes). The centipedes (fig. 1-4) are known as "hundred-leggers," although most species have fewer than this number of legs. The centipede has a head with one pair of antennae and a group of similar segments called a trunk. Each trunk segment bears a single pair of legs.

Centipedes range in size from small specimens less than 1 inch long to specimens in the Tropics reaching 10 inches. They are swift moving, nocturnal, secretive, predaceous, and terrestrial. Most species lay eggs. The young closely resemble the adults but sometimes have fewer leg pairs. They are beneficial to humans because they feed on many harmful insects. However, some species are capable of inflicting painful bites with their paired poison claws (modified first leg pair), but no dangerous species are found in the United States.

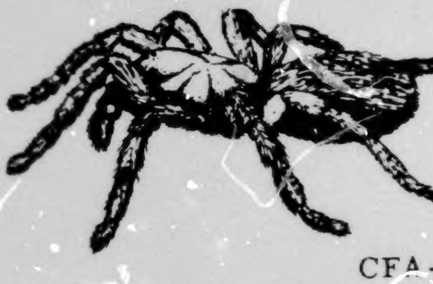

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Figure 1-3. Class Arachnida, a spider.

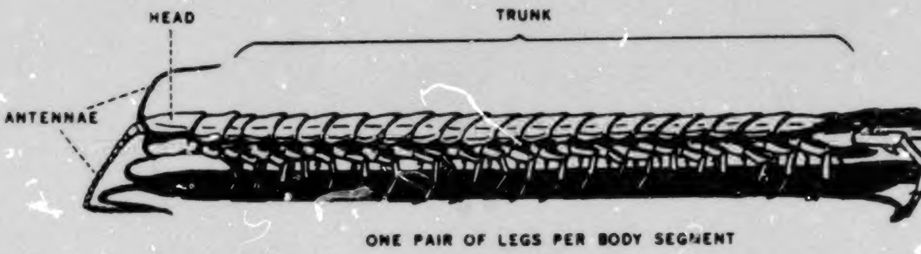

Figure 1-4. Class Chilopoda, a centepede.

The Class Diplopoda (millipedes). The millipedes (fig. 1-5) have one pair of antennae and two body regions, the head and trunk. They differ from centipedes in that each apparent trunk segment bears two pairs of legs. Millipedes usually do not injure man but may damage some of his plant crops.

Millipedes range in size from less than 1 to 5 or 6 inches. They are slow moving despite numerous legs, and are nocturnal, secretive, vegetarian, and terrestrial. They lay eggs, and the young resemble the adults but have fewer abdominal segments and only three pairs of walking legs. They may be accidental parasites of humans, inhabiting the intestinal and urinary tracts. When disturbed, some produce offensive fluids from paired glands located in the abdomen and have been known to produce a dermatitis in humans.

The Class Crustacea (crabs, shrimp, lobsters, sow bugs, and copepods). Crustaceans (fig. 1-6) differ from insects in having five or more pairs of walking legs, two pairs of antennae in typical forms, two body regions (cephalothorax and abdomen), no wings, reproductive organs opening at the base of the walking legs, no tracheae, and great variations in shape.

This class is the least related to the insects of any of the other related classes in this phylum. It ranges in size from microscopic forms, such as the copepods, to crabs more than 3 feet long. The animals in this class are relatively active, diurnal, predaceous, parasitic, and vegetarian. They are usually aquatic or semaquatic, and many are both diurnal and nocturnal. Eggs are usually carried in sacs inside or outside the body. The immature stages sometimes resemble the adults (crayfish) and sometimes look very different from the adults (copepod). Many are beneficial to humans from the standpoint of food (crabs, lobsters, shrimp, etc.). Some are intermediate hosts of parasites, attaching tapeworms, flukes, and guinea worms. Some species are marine boring organisms such as the gribble (Limnoria sp). Pillbugs and sow bugs are occasionally greenhouse pests.

The Class ~~Insecta~~ Hexapoda (true insects). The insects are the most important members of the Phylum Arthropoda. Typical adult insects have one pair of antennae, three pairs of walking legs, and three body regions: head, thorax, and abdomen (fig. 1-7). Many insects, but not all of them, have wings. None of the other classes of arthropods have wings. The reproductive organs open at the posterior end of the abdomen.

The specific habits and life histories of the insects of importance to man will be discussed in succeeding paragraphs. Learn the identifying characteristics of each class of the Phylum Arthropoda, for these characteristics will aid you in understanding the individual insect species and their habits.

Exercises (204):

1. In order for an arthropod to be placed in the Class Insecta it must possess wings. (True/False)
2. From the standpoint of human suffering and economic loss, which phylum presents the most concern to man?
   Arthropoda
   Arachnida
   Chordata

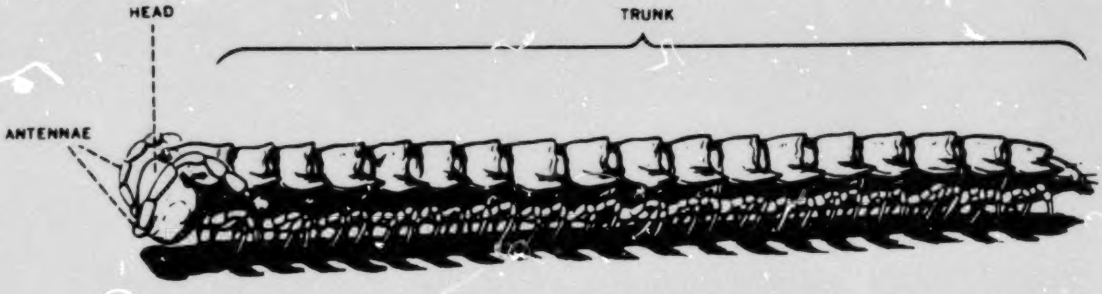

Figure 1-5. Class Diplopoda, a millipede.

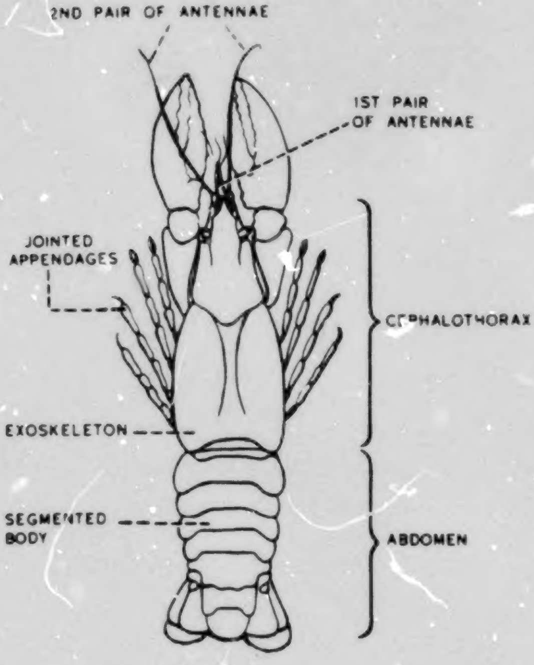

Figure 1-6. Class Crustacea, a crayfish.

3. The most important classes of arthropods discussed in this lesson are represented by which of the following groups?
   Arachnida and Chilopoda
   Chilopoda and Diplopoda
   ~~Insecta~~ and Arachnida
   Hexapoda

4. Which class is least related to insects but is still within the same phylum?
   Arachnida
   Crustacea
   Chilopoda

5. Match the following classes of arthropods with class identification:

Class	*Class Identification*
_____ a. Arachnida	1. Possess one pair of antennae, two body regions (head and trunk), and two pairs of walking legs on each trunk segment.
_____ b. Crustacea	2. The adult stage has no antennae or wings, bears four pairs of walking legs, and may have one or two body regions.
_____ c. Chilopoda	3. Have five or more pairs of walking legs, two pairs of antennae, two body regions, and without wings.
_____ d. Diplopoda	4. Possesses one pair of antennae, three pairs of walking legs, three body regions, and may or may not have wings.
_____ e. ~~Insecta~~ Hexapoda	5. Have one pair of antennae, two body regions (head and trunk), and one pair of legs on each trunk segment.

205. Identify structural characteristics and developmental processes of the Class Insecta.

Insect Structure and Development. An elementary knowledge of insect structure is necessary for the correct identification of insects, the first step in any study on insect biology or control.

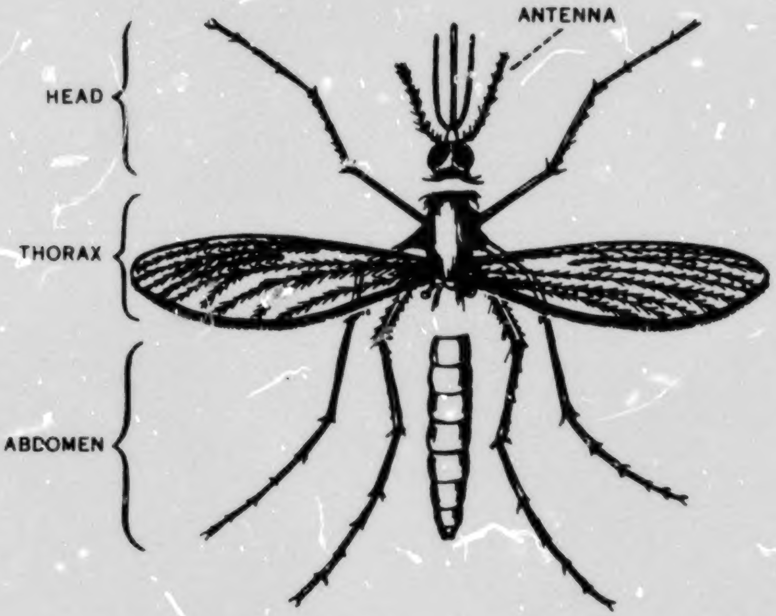

Figure 1-7. Insect (disarticulated) showing body regions.

One of the chief differences between an insect and man is in the skeleton. In insects, the "skin" has become hardened, almost like a suit of armor, into a stiff outer skeleton, or *exoskeleton*. This exoskeleton protects the internal organs from injury and serves as a framework for the attachment of muscles. By contrast, in humans and other vertebrate animals, the skeleton is inside the skin and is called an *endoskeleton*, as illustrated in figure 1-2.

In most insects, the outer parts of the body wall are hardened or sclerotized into plates, or *sclerites*, which are not flexible. These sclerites are jointed by flexible portions of the body wall called *intersegmental membranes*, which allow considerable movement, as when, for example, the abdomen of a mosquito becomes greatly distended during feeding. The sclerites may be covered with many small structures, such as hairs, scales, protuberances, and spines, many of which are useful in insect identification.

The body of an insect is divided into three main regions—the head, thorax, and abdomen (fig. 1-7). In the related Class Arachnida, called arachnids, the body is composed of only one or two main regions. The arachnids include ticks, mites, scorpions, spiders, and harvestmen.

The head. The anterior, or first body region, of an insect is known as the head. Its principal appendages (fig. 1-8) are the *mouthparts*, the *antennae*, the large *compound* eyes, and the simple eyes, or *ocelli*. Adult insects have only one pair of antennae; whereas the arachnids have no antennae, and crustaceans have two pairs of antennae.

Primitive insects have an upper lip, or *labrum*, a pair of mandibles, two *maxillae*, and a lower lip, or *labium*. There is an infinite variety of arrangements and forms of these parts. Three principal types are (1) chewing; (2) sponging; and (3) piercing-sucking.

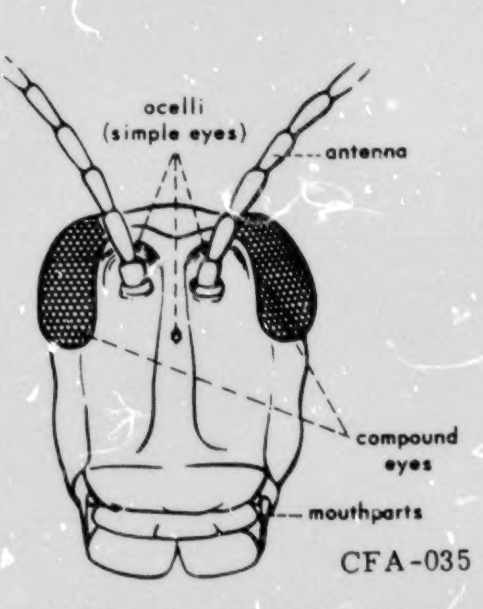

Figure 1-8. Head of an insect showing principal parts.

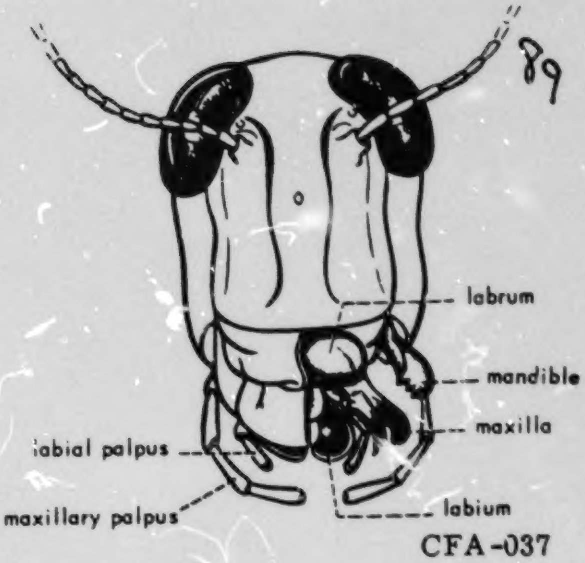

Figure 1-9. Chewing mouthparts.

Chewing mouthparts are possessed by insects that grind solid food (fig. 1-9). The mandibles are useful in cutting off food substances, such as the leaves of vegetable crops, and grinding them. The maxillae, labrum, and labium are used in manipulating this food before it is swallowed. The appendages known as the maxillary palpi and labial palpi assist in the feeding process and are used to taste, smell, and feel food. These appendages bear sensory hairs in which the various senses are concentrated. Some insects have another mouthpart, the tonguelike *hypopharnyx*. Most primitive insects, such as cockroaches and silverfish, possess chewing mouthparts.

Sponging mouthparts (fig. 1-10) are adapted for sucking liquid or readily soluble foods. These mouthparts have evolved from the more primitive chewing type of mouthparts. In these, the mandibles are absent and the maxillae are represented only by their sense organs, the palps. The housefly is typical of insects with sponging mouthparts. The labrum and labium have been jointed to form a *proboscis* with a spongy tip called the *labellum*. Flies thrust the proboscis into liquid or semiliquid foods such as milk and feces, and the capillary grooves on the face of the labellum carry the liquids to the food canal inside the proboscis. These insects can also eat sugar and other solid foods that are readily soluble. They regurgitate a drop of saliva on the sugar and cause it to dissolve, then pump the solution into the mouth as a liquid. Blowflies, houseflies, and flesh flies have sponging mouthparts and are therefore unable to bite.

Piercing-sucking mouthparts (fig. 1-11) are used to good advantage by mosquitoes, stable flies, sucking lice, fleas, and kissing bugs. Many of the bloodsucking vectors of disease have piercing-sucking mouthparts, which are constructed on different basic plans. In some, the mouthparts are modified to form a slender

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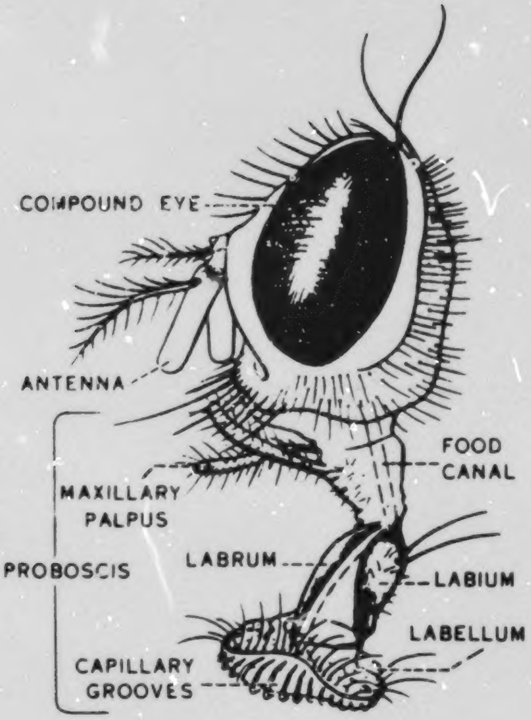

Figure 1-10. Sponging mouthparts.

beak or proboscis which encloses the stylets. The sucking lice have no proboscis, but the piercing mouthparts are retracted into the head.

True insects, millipedes, and centipedes have one pair of antennae, or feelers, located on the front portion of the head (fig. 1-8). Most crustaceans have two pairs of antennae, while arachnids have none. The more primitive insects, such as the silverfish and cockroach, have conspicuous antennae with many similar segments. In many insects the antennae are greatly modified and often have characteristic shapes that are useful in identification (fig. 1-12).

There are two types of eyes in insects—simple and compound (fig. 1-8). The simple eyes, or *ocelli*, consist of single eye units or *facets*. In many insects three ocelli are arranged in the form of a triangle between the large compound eyes. The compound eyes are usually very large and are round, oval, or kidney-shaped. The outer face of the compound eye is composed of many small six-sided lenses called *facets*. In the ant, the eye has from 50 to 400 facets; whereas in the dragon fly, it may have more than 25,000 facets. The size of the eye appears to be related to the demands for accurate vision in the normal life of the insect. In general, the active flying insects have large eyes with many facets, while in the more pedestrian types such as beetles and ants, the eyes have fewer facets. Some parasitic insects have poorly developed eyes, or the compound eyes may be absent, as in certain fleas and lice.

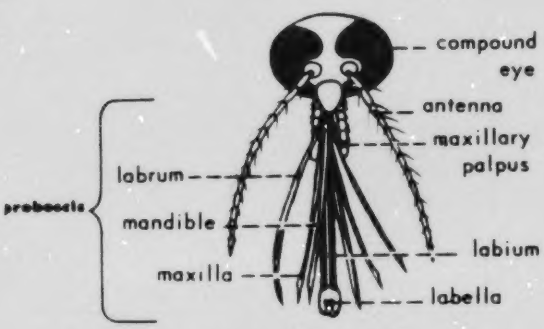

Figure 1-11. Piercing-sucking mouthparts.

The thorax. The insect thorax, or chest, is the second main body region (fig. 1-13). It is connected to the head by a membranous region, the neck, or cervix. The thorax is composed of three segments made up of varying numbers of sclerites, or plates. Each segment bears one pair of legs. The segments are designated *prothorax*, *mesothorax*, and *metathorax* to indicate their position. Each of these three segments of the thorax is composed of plates with names that are often used in identification. The plate on the top or dorsal side of each thoracic segment is called the *tergum* or *notum;* on each side, a *pleuron;* and on the bottom or ventral side, the *sternum*. In identifying insects, the shape or color pattern of the various parts of the thorax is frequently used in identification. For instance, in cockroaches, the large oval plate covering the head is the notum of the prothorax, or *pronotum*, while in mosquitoes, the large plate between the wings is the notum of the mesothorax, or *mesonotum*. The color pattern on the pronotum or mesonotum of these insects furnishes good characters for quick identification in the field. Wings, when present, are attached to the mesothorax and metathorax, the last two thoracic segments.

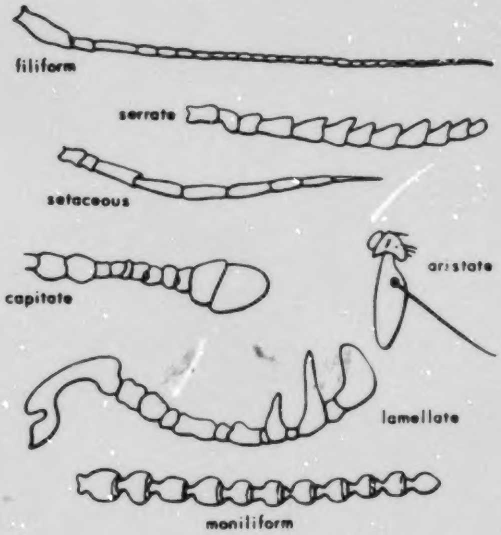

Figure 1-12. Types of insect antennae.

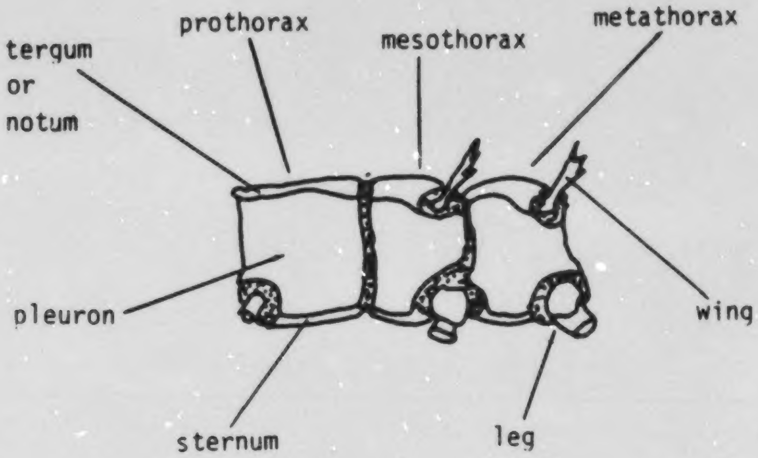

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Figure 1-13. Insect thorax.

The wings. Insect wings are membranous extensions of the body wall having an upper and lower layer supported by reinforcing structures called *veins.* Wing veins running from the base of the apex, or point of the wing, are called *longitudinal veins.* The *cross veins* run crosswise to the wing and connect the longitudinal veins. The arrangements and number of wing veins (fig. 1-14) offer important characters for identification of insects. Many of the standard entomological textbooks, as Comstock (1940), have a detailed discussion of wing venation.

Insects typically have two pairs of wings, although certain groups, such as the flies, have lost the second pair as flying wings. The second pair remain in rudimentary form as small knobs or balancers called *halteres.* Insects possessing two pairs of flying wings may use them independently or may have them coupled together, as in some of the butterflies, bees, and wasps. The forewings in certain orders of insects are adapted as wing covers which will be discussed under the Orders Hemiptera, Orthoptera, and Coleoptera.

The legs. The leg is divided into a *coxa, trochanter, femur, tibia, tarsus,* and *pretarsus.* Figure 1-15 illustrates some of the many types of insect legs. The femur and tibia correspond to the human thigh and shin, and the tarsus has a function similar to that of the foot. Some of the tarsal segments may bear pads, or *pulvilli,* which assist the insect in walking on smooth surfaces, such as glass. The legs of lice are short and stout and modified into claw-like structures for grasping and holding on to hairs. Legs of fleas and cockroaches are well developed and elongated for jumping or running.

The abdomen. The abdomen, or third body region (fig. 1-16), is made up of segments with *dorsal tergites* and *ventral sternites.* It bears the spiracles and the external reproductive organs. The *spiracles* are the external openings of the respiratory system. In most insects the last segments bear the external sex organs used for copulation in the male and the egg-laying device, or *ovipositor,* of the female. Some insects bear a pair of *cerci* (singular cercus) near the tip.

The development. The life cycle begins with the fertilization of the egg and is completed when the adult stage is reached. The term "lifespan" refers to the entire length of life of the insect. Some insects, such as tropical termite queens, may live 15 or 20 years; and the periodical cicada lives for 14 to 17 years. Mayflies may live only a few days as adults, although they may spend two or three years in the developing immature stages.

Small animals have relatively greater surface areas in proportion to their body weight and volume than large ones. This results in increased evaporation of water vapor from the body and requires the development of complex waterproof body coverings. The hard plates in the cuticle also serve as protective armor as well as body support and as the framework for muscles of locomotion.

The development of this armor-like exoskeleton and wings has complicated the growth of insects. The molting process is a means by which an immature insect may shed this protective skeleton, the linings of the respiratory system and of the foregut and hindgut. A molting fluid is produced between the old exoskeleton and the new soft cuticle of the insect. Air or

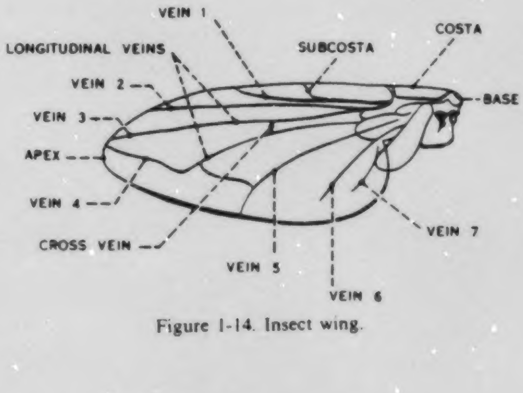
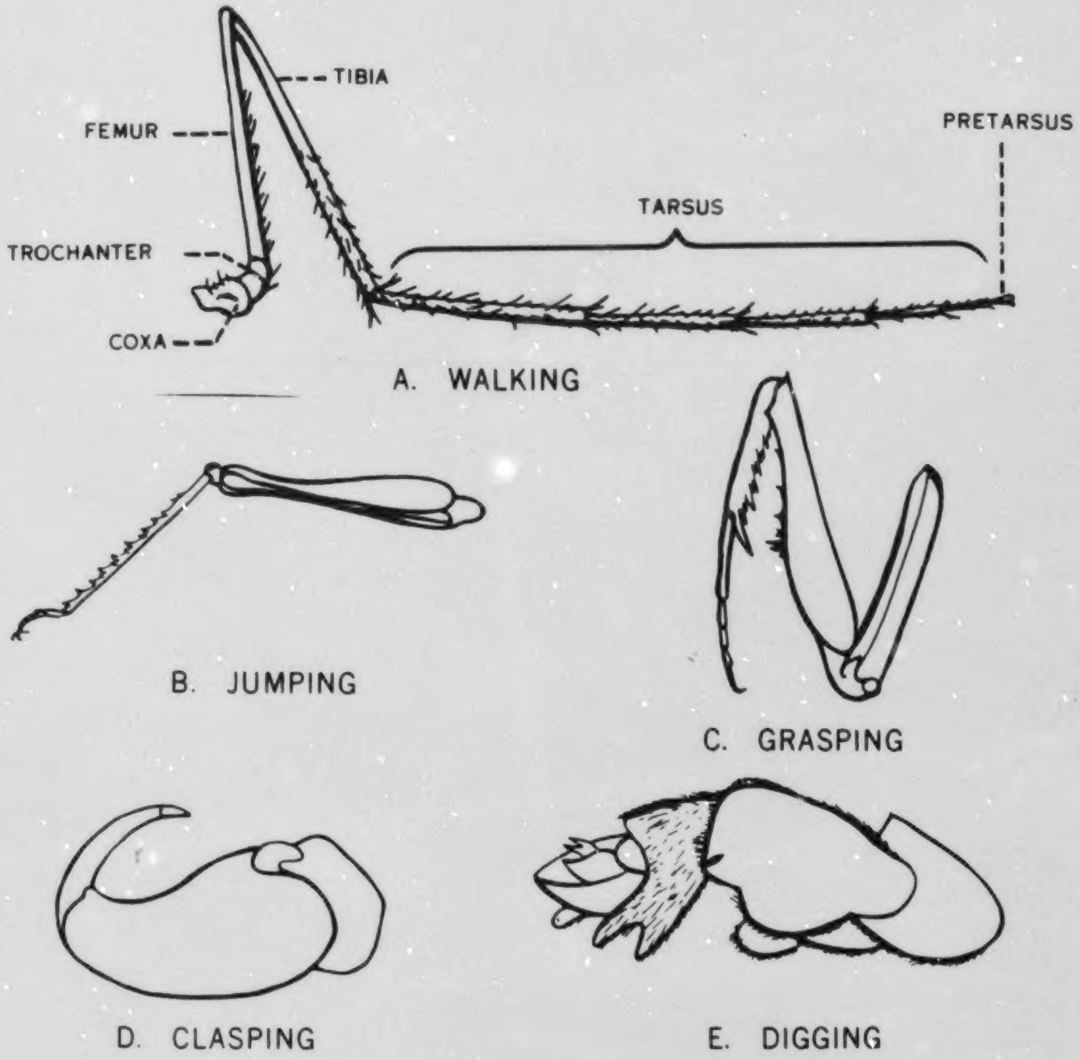


Figure 1-14. Insect wing.



A. WALKING

B. JUMPING

C. GRASPING

D. CLASPING

E. DIGGING

Figure 1-15. Insect legs.

water is swallowed until the body swells, bursting the old cuticle on the dorsal surface in most cases. The insect gradually extracts itself; and a new cuticle hardens on its expanded body, thus accomplishing a stage of growth. The number of molts is small and constant in most species, such as the three molts of the housefly; or it may be large and variable as in the 12 or more molts of the American cockroach. For a period varying from a few hours to a day after molting, the body of an insect may be soft and pale colored, leading some laymen to refer to it as an "albino." However, during the first day after molting, there is a progressive hardening and coloring of the integument, and for this reason, most entomologists allow newly emerged adult insects to remain in rearing containers for 12 to 24 hours before killing and pinning them. For example, if mosquitoes are killed soon after they emerge, their abdomens will shrivel before the integument becomes hardened, making it difficult to identify them.

Metamorphosis refers to changes in form or structure of an insect during its development. A few primitive insects develop without metamorphosis. The young possess all of the obvious structures of the adult and differ from them merely in size, color, and sexual maturity. The springtails (Collembola) and silverfish (Thysanura) develop without metamorphosis. Both are small wingless insects. Thysanura grow and molt throughout life so that there is no distinct adult stage.

Insects with gradual or incomplete metamorphosis pass through three stages during their life: *egg*, *nymph*, and *adult*, as illustrated in figure 1-17. Insects in this group change gradually while going through a succession of molts to become adults. The young resemble the adult insect except for their smaller size and for the absence of wings in wingbearing species.

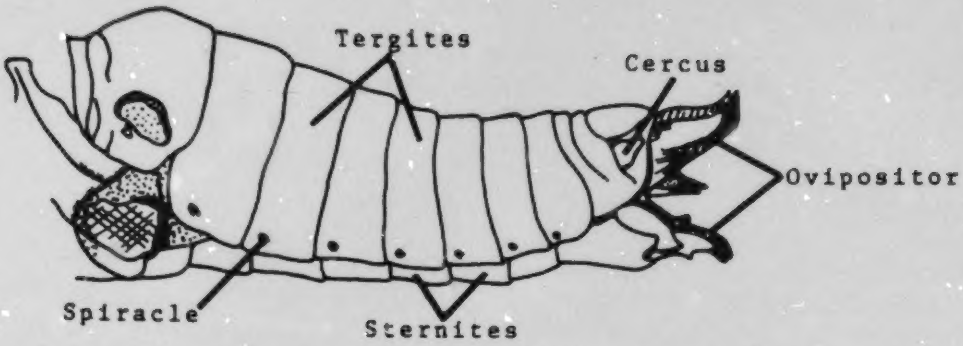


Figure 1-16. Insect abdomen.

The young, or nymphs, are immature sexually and may bear wing pads in the latter stages of their development. Some important orders with gradual metamorphosis are:

DICTYOPTERA	cockroaches, walking sticks, and praying mantids.
ANOPLURA	sucking lice, including the crab and body lice.
MALLOPHAGA	biting lice.
HEMIPTERA	true bugs including the bedbug and kissing bug.
DERMAPTERA	earwigs.
PSOCOPTERA	book lice and psocids.

Insects with complete metamorphosis have four stages: *egg, larva, pupa,* and *adult,* as illustrated in figure 1-18. Insects with this type of life history are greatly different in the immature and adult stages. Typical larvae are the wigglers of mosquitoes, the maggots of flies, or the caterpillars of butterflies and moths. The pupal stage is an important evolutionary development during which the simple larva undergoes many external and internal changes to become the complex adult.

Most of the insects with complete metamorphosis have wings as adults, but some species, such as the fleas, are completely wingless. Normally the wing buds first appear in the pupal stage. When the young adult first emerges from the pupal shell, the wings are crumpled and useless. Hydrostatic pressure of the blood within the insect body forces the sac-like wings outward, and the two membranes collapse against each other to form the single membranous structure.

There are many orders of insects having complete metamorphosis. Five of these orders of most importance to pest managers are listed below:

DIPTERA	flies, mosquitoes, midges, and punkies.
SIPHONAPTERA	fleas.
LEPIDOPTERA	moths, butterflies, and skippers.
HYMENOPTERA	ants, bees, and wasps.
COLEOPTERA	beetles and weevils.

Exercises (205):

1. An insect's body is divided into ____________ main body regions.
2. An insect's skeleton actually consists of skin that has become hardened; the term applied to this hardened skin is ____________ .
3. Insect spiracles are used for ____________ and are located on the ____________ region.
4. Halteres are possessed by ____________ and are actually ____________ that serves as ____________ organs.
5. The metathorax is the ____________ segment of the ____________ .
6. Place a C for correct statements and place an I for the incorrect statements concerning insect morphology.

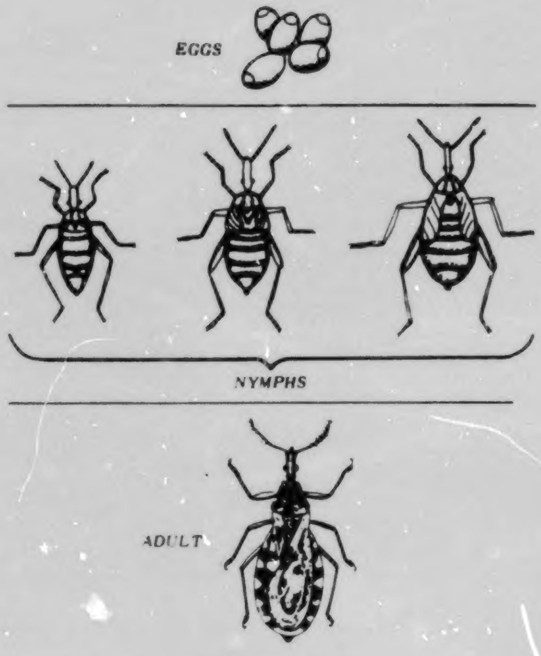


Figure 1-17. Gradual metamorphosis.

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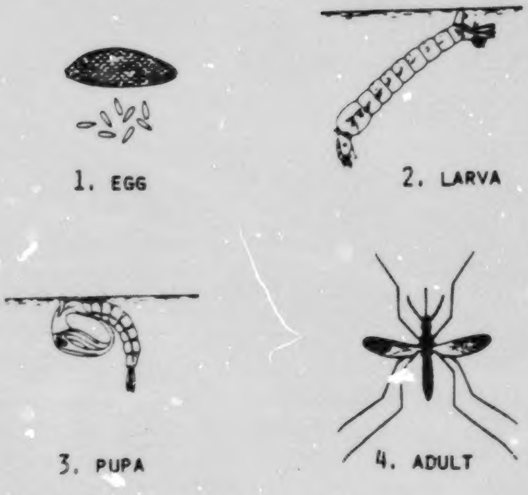

Figure 1-18. Complete metamorphosis.

____ a. The wings and legs are attached to the abdomen.

____ b. The wings and legs are attached to the thorax.

____ c. The legs are attached to the abdomen and the wings are attached to the thorax.

____ d. The legs are attached to the thorax and the wings are attached to the abdomen.

7. When a change in form or structure occurs during the development process of an insect, this is referred to as ____________ .
8. Insects that pass through three stages during their life are known as having ____________ .
9. Insects that pass through four stages of development during their life are known as having ____ .
10. Insects that pass through no recognizable change except increasing in size in the development process are insects that develop ______________ .
11. Insects that have a gradual metamorphosis go through several gradual changes within the nymphal stage. The term applied to each of these development changes is ____________ .

206. Identify the distinguishing characteristics of important orders within the Class ~~Insecta~~.
Hexapoda

Order of Insects. The Class ~~Insecta~~ Hexapoda is divided into some 20 to 40 major groups or orders by different authorities. Members of each order have certain features in common that distinguish them from all other insects, primarily the type of mouthparts, the number of pairs and type of wings, and the kind of metamorphosis.

You will not be expected to learn the genera or species of all insects with which you come in contact, but you should learn whether they are flies, beetles, or moths. These words are used loosely by many people, and reports will come in stating that a quarters is infested with "flies" when it is really infested with cereal moths or "beetles." The main orders of common insects and a brief description of their characteristics are given in the following paragraphs.

Order Anoplura (unarmed tail). The sucking lice (fig. 1-19) are small, wingless, flattened insects that are bloodsucking parasites of man and other mammals. The species most important to public health are the body louse, the head louse, and the crab louse. Their mouthparts, which are usually retracted within the head, are modified for piercing and sucking. Their eggs, or nits, are attached to the body hairs or (in humans) to the undergarments. Development is by gradual metamorphosis.

Order Coleoptera, (sheath wing—beetles and weevils). In the adult stage, the beetles and weevils (fig. 1-20) have four wings. The front pair are heavy and shell-like and serve as wing covers, called *elytra*, which protect the hindwings and the abdomen. The hindwings are membranous or cellophane-like and fold underneath the forewings. The mouthparts are fitted for chewing, some of which have mouthparts extended into a snout (these are the true weevils). Beetles have complete metamorphosis.

Order Dermaptera (skin wing—earwigs). Earwigs (fig. 1-21) are rather small, dark-colored insects with a long, narrow body and a prominent pair of cerci, or forceps, at the posterior end. The head bears chewing type mouthparts and relatively short antennae. The forewings are short, leathery structures which protect the delicate semicircular hindwings that are pleated like a fan. Earwigs are primarily vegetarians but will invade houses by the thousands, and if crushed they give off an offensive odor and can be severe household pests. Despite their name, "earwigs" are not guilty of entering the human ear and stinging a person to death, as related in some old wives' tales.

Order Diptera (two-winged—flies and mosquitoes). The flies (fig. 1-22), mosquitoes, gnats, midges, and punkies make up this large order of two-winged insects. A pair of knobs, or halteres, occurs in place of the second pair of wings. Some forms, such as the "sheep tick," or ked, lack both wings and halteres. Mouthparts are fitted for sucking or lapping. These insects undergo complete metamorphosis, and the

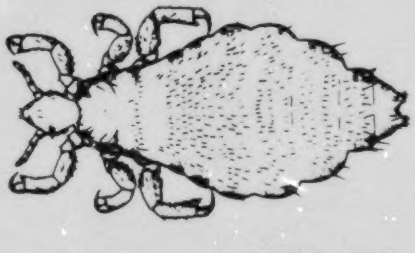
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Figure 1-19. Order Anoplura, a body lice.

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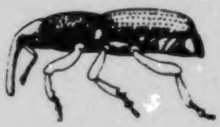

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Figure 1-20. Order Coleoptera, a grain weevil.

larvae are called "maggots" or "wigglers," depending upon the species. Some diptera are beneficial; many are neutral to man, and many are serious pests and vectors of disease.

Order Hemiptera (half-winged—true bugs). This large order comprises the true bugs (fig. 1-23), the only insects properly called by that name. The young or nymphs, go through a series of molts before reaching the adult stage, and thus develop by gradual metamorphosis. The adults generally have two pairs of wings. The forewings of these bugs are diagonally divided into two parts, the forepart and the hindpart. The forepart is thickened and the hindpart is membranous. Not all of these insects have wings but may have rudimentary (partial) wings. The bedbug is an example of this. Bugs have a scutellum, a triangular body area between the bases of the overlapping forewings. The mouthparts are modified into a beak for piercing and sucking.

Order Homoptera (same wing—aphids and scale insects). This name is not a very good guide, because some have no wings (the nonreproductive generations) and others have dissimilar wings (leaf hoppers). The Homoptera (fig. 1-24) share certain characteristics with the Hemiptera (half-wings), with which they were once grouped. They have piercing, sucking mouthparts which are like jointed tubes. They have incomplete metamorphosis.

Order Hymenoptera (membrane winged—ants, bees, and wasps). Hymenoptera (fig. 1-25) are distinguished from most other insects by their four small membranous wings with few veins. The hindwings are smaller than the forewings. The mouthparts are suited for chewing or lapping. Many species have the apparent first segment of the abdomen reduced to a slender waist, as in the ants. The abdomen joins onto the thorax by a narrow waist, or "petiole" (PET-tee-ole) from which we get the expression "wasp-waisted." The common ant is an immature, wingless female called a worker. However, the mature male and some female ants do have wings. Some wasps do not have wings (the so-called velvet ants, or cow killers) but are hairy and have infinitely painful stings. Wasps, hornets, mud daubers, and bees are all relatives in their order. However, only the immature female worker, the queen ant or queen bee, the female of the mud dauber, and the carpenter and solitary bees can sting. This is made possible by modification of the egg-laying apparatus which forms the stinger. The Hymenoptera are the most beneficial of all insects, only a few being harmful. They furnish food for man and pollination for fruit and grain products.

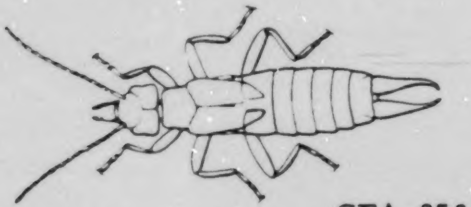

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Figure 1-21. Order Dermaptera, an earwig.

Order Isoptera (equal winged—termites). Termites (fig. 1-26) in the immature or work stages or in the soldier caste do not have wings, but the mature male and female have identical wings. When wings are present, there are two pairs which are membranous with reduced venation, and both pairs are the same size and shape. They have mouthparts adapted for chewing and undergo gradual metamorphosis.

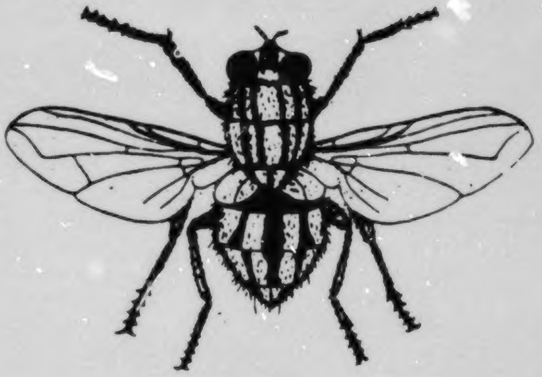

Figure 1-22. Order Diptera, a housefly.

Order Lepidoptera (scale winged—butterflies and moths). Moths (fig. 1-27) and butterflies are distinguished from all other insects by their large, showy wings. The wings are usually completely covered with very small colored scales which rub off as a fine powder when the specimens are handled. Mouthparts are of the sucking type, resembling a coiled watch spring beneath the head. The larvae are caterpillars, and metamorphosis is complete.

Order Mallophaga (wool eater—chewing lice). Biting lice (fig. 1-28) are external parasites, chiefly on birds (hence one name, bird lice), although a few live on mammals. They are wingless and have chewing mouthparts for feeding on scales, feathers, hair, or oily secretions from the skin. The eggs are glued to feathers or hairs, and the young lice, called nymphs, and the adults spend their entire lives on the host animal. Development is by gradual metamorphosis.

Order Dictyoptera (straight winged—cockroaches). The cockroaches (fig. 1-29), walking sticks, praying mantids, and other species belong to this order have the chewing mouthparts. When wings are present, the forewings are thickened and leathery and have a

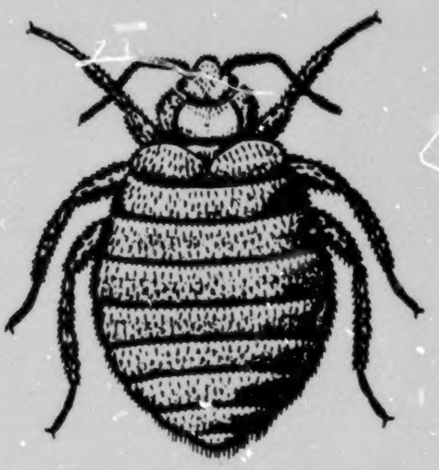

Figure 1-23. Order Hemiptera, a bedbug.

net venation, while the hindwings are folded beneath the forewings like a fan. Cockroaches have long antennae and legs modified for running. Their bodies are flattened from top to bottom, an adaptation that enables them to hide easily in cracks or under furniture. These primitive insects develop through a series of nymphal stages by gradual metamorphosis.

Order Psocoptera (small winged—psocids). Psocids (fig. 1-30) are very small, soft-bodied insects which may or may not have wings. When wings are present they may be long or short, depending upon specie, and normally there are two pairs. The forewings are a little larger than the hindwings, and when this insect is in a resting position, the wings are folded back in a rooflike fashion over the abdomen. Psocids have chewing mouthparts and the metamorphosis is complete.

Order Siphonaptera (tube and wingless—fleas). Fleas (fig. 1-31) are wingless bloodsucking parasites of birds and mammals. They are very small and their bodies are compressed laterally so that they are quite narrow from side to side. The head bears piercing-sucking mouthparts and antennae, and it may, or may not, bear a pair of eyes. The legs are well developed and fitted for jumping. Many species have black combs, or *ctenidia,* on the thorax and head. Fleas go through complete metamorphosis, with four life stages; the egg, a wormlike larva, the pupa in a silken cocoon, and the adult.

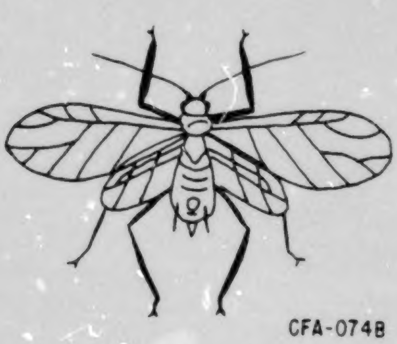

Figure [illegible] Order Homoptera, an aphid

Order Thysanoptera (fringe wing—thrips). Thrips (fig. 1-32) have piercing-sucking mouthparts which are cone shaped. The wings when present are very hairy, which give them their feathery appearance; there are two pairs. The metamorphosis is somewhat complicated in that their development is intermediate between gradual and complete.

Order Thysanura. Silverfish (fig. 1-33) and firebrats have chewing mouthparts, scales on their bodies, and three long appendages at the posterior end of the body. The young possess the obvious structures of the adults and differ from them chiefly in size, color, and sexual maturity.

The order of insects just described do not represent all of the insect orders, just the orders of the more common insects. The probability of your coming in contact with these insects makes it important that you learn to identify them individually as well as by order.

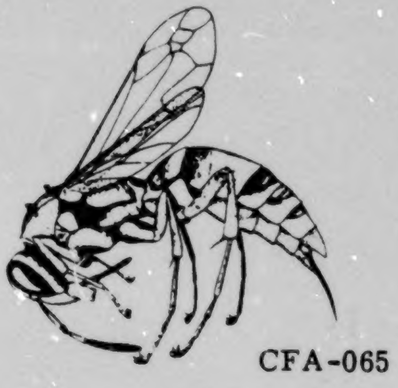

Figure 1-25. Order Hymenoptera, a wasp.

Exercises (206):

Match distinguishing characteristics with the appropriate orders of insects.

Order of Insects

_____ 1. Anoplura
_____ 2. Coleoptera
_____ 3. Dermaptera
_____ 4. Dictyoptera
_____ 5. Diptera
_____ 6. Hemiptera
_____ 7. Homoptera
_____ 8. Hymenoptera
_____ 9. Isoptera
_____ 10. Lepidoptera
_____ 11. Mallophaga
_____ 12. Psocoptera
_____ 13. Siphonaptera
_____ 14. Thysanoptera
_____ 15. Thysanura

Distinguishing Characteristics

a. Two-winged insects having halteres that replace the second pair of wings and mouthparts adapted for sucking or lapping.
b. Small, wingless, flattened insects with mouthparts usually retracted within the head and modified for piercing and sucking.
c. An insect order that contains insects that are wingless in the adult stage and have chewing mouthparts. The adults spend their entire lives on animal hosts.
d. This insect order contains insects that have cone-shaped piercing and sucking mouthparts. When wings are present they are very hairy and appear to be feathery.

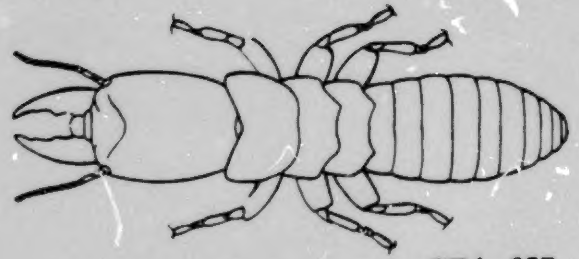

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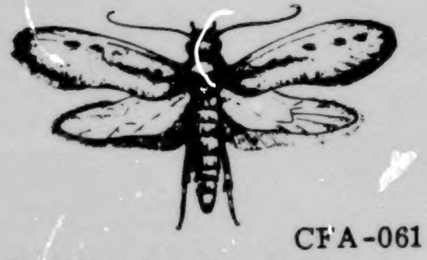
Figure 1-26. Order Isoptera, a termite.

e. This order of insects has piercing and sucking mouthparts that are similar to jointed tubes. Some of the insects within this order have no wings while others have dissimilar wings.
f. This order of insects can be distinguished from all other orders by having large, showy wings that are usually completely covered with very small colored scales. The mouthparts are the sucking type and are coiled beneath the head.
g. The order of insects having chewing mouthparts, scales on their bodies, and three long appendages at the posterior end of the body.
h. Rather small, dark-colored insects with a long, narrow body and a prominent pair of cerci at the posterior end. Heads bear chewing mouthparts and relatively short antennae. The forewings are short leathery structures and protect the delicate semicircular hindwings which are pleated like a fan.
i. This order of insects, described as being very small and soft bodied, may or may not have wings. When wings are present the forewings are a little larger than the hindwings and the wings are folded back in a rooflike fashion over the abdomen when in a resting position. The mouthparts are adapted for chewing.
j. This order of insects, when in the mature stage, has two pairs of identical wings that are membranous with reduced venation. The mouthparts are adapted for chewing.



CFA-061

Figure 1-27. Order Lepidoptera, a grain moth.

k. Adult insects that generally have two pairs of wings. The forewings are diagonally divided into two parts, the forepart being thickened with the hindpart being membranous. This order of insects has a scutellum and mouthparts modified into a beak for piercing and sucking.
l. The order of insects that is described as being very small, wingless, and parasites of birds and mammals. The mouthparts are adapted for piercing and sucking, bodies are compressed laterally, and the legs are developed for jumping.
m. The order of insects having chewing mouthparts with bodies flattened from top to bottom and legs adapted for running. If wings are present, the forewings are thickened and leathery and have a net venation. The hindwings are folded beneath the forewings like a fan.

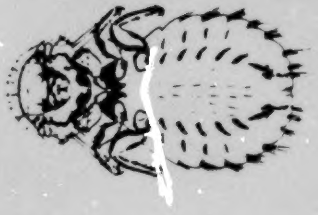


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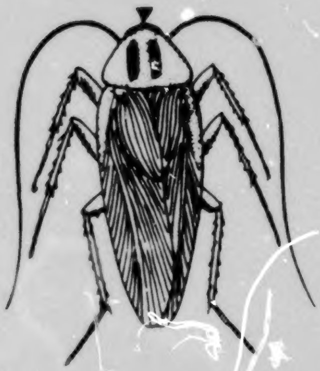
Figure 1-28. Order Mallophaga, a biting louse.

n. This order of insects has mouthparts designed for chewing, some of which are extended into a snout. The front pair of wings are heavy and shell-like and the hindwings are membranous or cellophane-like and fold underneath the forewing.
o. Distinguished from other orders of insects by having four small membranous wings with few veins. Hindwings are smaller than the forewings. In this order of insects the mouthparts are suited for chewing and lapping and in many species the apparent first abdominal segment is reduced to a slender waist.

207. Identify the distinguishing characteristics of important orders within the Class Arachnida.

Important Orders of Arachnids. Although there are several orders in the Class Arachnida, we are interested in only three: Scorpionida (scorpions), Araneida (spiders), and Acarina (ticks and mites).



CFA-055

Figure 1-29. Order ~~Dictyoptera~~, a cockroach.
Dictyoptera

Order Scorpionida (scorpions). Scorpions (fig. 1-34) are arachnids with the segmented abdomen broadly joined to the cephalothorax and ending in a stinger. The long, slender tip of the abdomen bears a stinger, enclosing a venomous gland, which is used to paralyze prey and as a defensive weapon. The large pincerlike palps used to catch and hold prey are borne in front of the first pair of legs.

Order Araneida (spiders). Spiders (fig. 1-3) differ from other arachnids in having the cephalothorax joined to the abdomen by a slender waist, known technically as a *pedicel,* and having the abdominal segmentation either indistinct or absent. Spiders are generally harmless and serve a useful purpose in destroying flies, mosquitoes, and other insects. However, some species of Widow spiders, which have an hourglass marking on the underside of the abdomen (genus *Latroductus),* have a very venomous bite that is known to kill people. The bite of spiders in the genus *Loxosceles* in the Americas can cause skin gangrene and sometimes death.

Order Acarina (ticks and mites). Ticks and mites (fig. 1-35) have the head, thorax, and abdomen combined into a single body region, and are often saclike in form. Most ticks bear a *hypostome* provided with recurved teeth, which is used as a holdfast organ after the mouthparts, called *chelicerae,* have made an incision into the flesh of most mammals, birds, reptiles, and amphibians in order to obtain blood. Mites are usually much smaller than ticks, and the hypostome, if present, is not armed with teeth. Ticks and mites have three pairs of legs in the first or larval stage, but typical nymphs and adults have four pairs of legs. Next to the insects, ticks and mites are the most important arthropod vectors of human diseases.

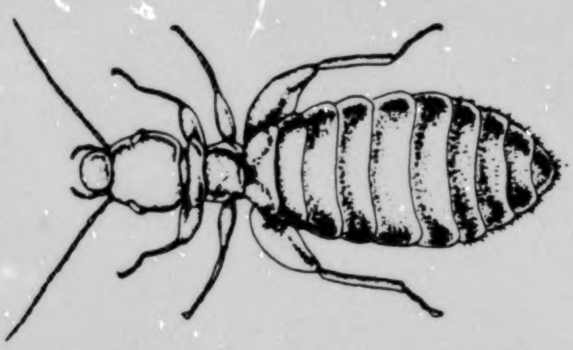


Figure 1-30. Order Psocoptera, a psocid.

Exercises (207):
Match the following adult characteristics of the Class Arachnida to the proper order.

Adult Characteristics	*Order*
_____ 1. The head, thorax, and abdomen are combined to form a single body region.	a. Scorpionida b. Araneida c. Acarina

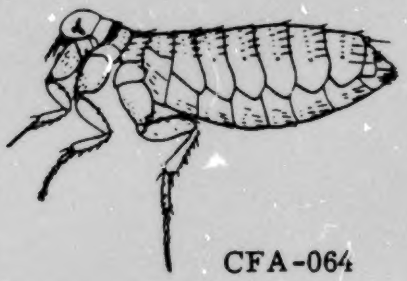


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Figure 1-31. Order Siphonaptera, a flea.

_____ 2. The abdomen is segmented and broadly joined to the cephalothorax and ends with a stinger.

_____ 3. The cephalothorax is joined to the abdomen by a slender waist.

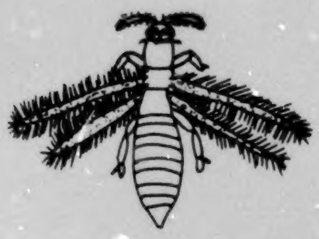
1-3. Arthropod Physiology

Insect physiology deals with the functioning of cells, organs, and tissues which are involved in maintaining life processes of insects.

In this section we will discuss the internal structure of insects and compare the life processes of insects with higher animals. The sensory organs of the insect will also be discussed because these are very important points that must be fully understood by entomologists within the Air Force in order to manage insects effectively.

208. State the functional purposes of the main body systems of insects, and identify their internal structures and life processes.

The Internal Structure and Physiology of Insects. Insects have all the major body systems that are found in higher animals. Insects and humans differ not only in their skeletal system, but also in the arrangement



CFA-074A

Figure 1-32. Order Thysanoptera, a thrip.

of their major internal organ systems. The positions of the "heart," or chief circulatory organ, and the nervous system are the exact opposite in the insect and in man. In the insect the "heart" is on the dorsal, or upper side, and the central nerve cord is on the ventral, or underside. In man, by contrast, the heart is on the ventral side and the main nerve cord is encased in the spinal cord on the back, or dorsal side.

The circulatory system. The insect circulatory system is an "open" one in the sense that the blood is not enclosed in blood vessels but circulates freely throughout the body cavity. The blood seeps into the *heart* or *dorsal blood vessel* through valves (ostia) and is pumped into the head region through the anterior part called the *aorta* (fig. 1-36). From the head region the blood flows backwards, bathing the various tissues. In the legs and antennae, small pulsating organs help circulate the blood. Typically, the blood is colorless or greenish yellow. Only in a few insects, such as the bloodworm midge larvae (Chironomus), does the blood have a reddish color due to hemoglobin. The blood does not bear oxygen and carry off carbon dioxide and serve as a part of the respiratory system as in the higher animals. One of its main functions is to remove waste products from body cells and carry them to the malpighian tubules. Insect blood contains phygocytes that perform the usual function of destroying foreign matter and plugging wounds in the body wall.

The nervous system. The insect nervous system (fig. 1-37) contains nerve tissues and organs much like those found in the higher animals. The *brain* lies in the head above the esophagus and is connected to the subesophageal ganglion by two nerve cords encircling the esophagus. A double nerve cord extends backward along the ventral surface of the body cavity. In primitive insects each segment of the thorax has a nerve center or *thoracic* ganglion. They also have a *ganglion* (plural, *ganglia*) in each abdominal segment, but these have been reduced in most of the higher insects.

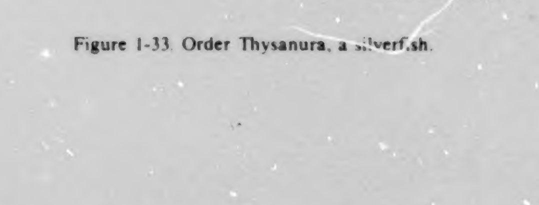


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Figure 1-33. Order Thysanura, a silverfish.

The respiratory system. Air enters the insect body through *spiracles*, or external openings on the body wall, into large *tracheal trunks* which usually extend the length of the body. Many tracheae branch off these main trunks and carry air to the tissue through their finely branched tracheoles (fig. 1-38).

Respiratory movements of the insect body alternately compress and expand the large tracheal trunks, thereby ventilating the main branches of the respiratory system. Some insects are able to regulate the flow of air, taking it in through anterior spiracles and expelling it through posterior spiracles. Mosquito larvae breathe air through two openings, at the tip of the air tube in culicine, or on a spiracular plate in anopheline larvae.

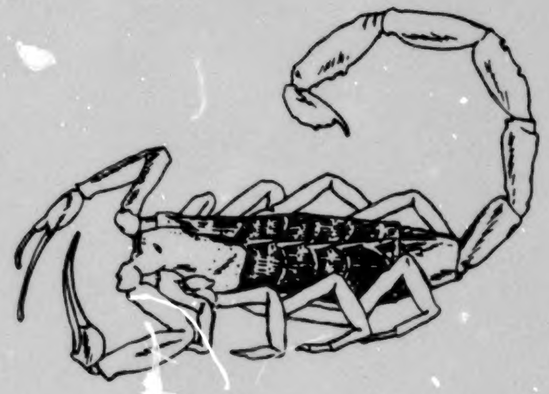


Figure 1-34. Order Scorpionida, a scorpion.

Oxygen is carried to all parts of the insect body by these tracheal tubes. This same system also acts to carry waste carbon dioxide from the body tissues. Considerable loss of water through this system would occur if it were not for the presence of valves in the spiracles. In some insects these openings are regulated by the presence of carbon dioxide, an excess of this gas causing them to open. Oxygen requirements of insects are of the order of 1 cubic millimeter of oxygen per gram of body weight per hour, varying greatly with species and circumstances, such as temperature and humidity.

The digestive system. Insects feed on a variety of foods, such as blood, animal tissue, stored foods, green grass, plant juices, and wood. The mouthparts and digestive system [illegible] adapted to changing these complex foods into simple carbohydrates, fats, and proteins that will nourish the body cells. The digestive system consists of an alimentary canal, which is basically a tube running from the mouth to the anus. It is divided into a *foregut, midgut,* and *hindgut* corresponding to its embryological origin (fig. 1-39).

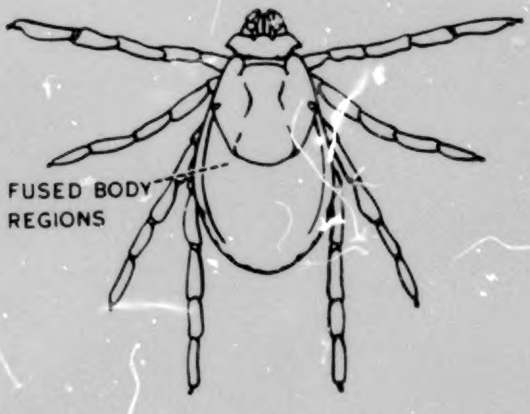


Figure 1-35. Order Acarina, a tick.

The food taken into the mouth passes through the *oesophagus* to the crop, which is an enlarged portion of the foregut that is used for food storage. Some insects have a *proventriculus*, or gizzard, where food may be ground into finer particles. The food then passes into the stomach, or midgut, where digestion takes place. The undigested food then passes out through the *intestine* and *anus* as feces. Most insects have salivary glands and gastric caeca to provide enzymes for food digestion.

The excretory system. An arthropod's undigested food is expelled from the body as feces, whereas the excretions of true body wastes, the byproducts of growth and metabolism, are carried by the blood and the *malpighian tubules* and discharged into the intestine near the junction of the *midgut* and the *hindgut* (fig. 1-39).

The reproductive system. Most insects have two sexes, which must mate before eggs are produced. An insect usually produces large numbers of eggs, although some species produce very few eggs and others may produce living larvae. Insects laying eggs are said to be *oviparous*, while those species depositing larvae are said to be *larviparous*. The Tsetse fly, for example, gives birth to larvae already full grown and ready to pupate.

A few insects have only one sex, the female, which can produce young without fertilization by a male, as in the Surinam cockroach. This type of reproduction is called *parthenogenesis*, or virgin birth. These insects are not hermaphrodites, since no male organs are present.

The *male reproductive system* (fig. 1-40) consists of a pair of *testes* in which sperm cells are developed, and ducts, or *vas deferens*, leading to the *penis* or ejaculatory organ. The *seminal vesicle* serves as a reservoir for storing sperm cells until mating occurs. The *accessory* glands secrete a liquid substance to serve as a vehicle for the sperm cells.

The *female reproductive system* (fig. 1-41) consists of a pair of *ovaries*, which produce eggs (ova), and the *oviduct* through which the eggs pass into the *vagina*, where they may be fertilized by male sperm cells stored in the *spermatheca* (or spermathecae). Some species have *accessory* glands that secrete an adhesive coating for the eggs. A single copulation usually supplies the female with enough sperm to fertilize a large number of eggs, whether she lays them all at one time or at intervals over a long period.

The skeletal system. We have mentioned the skeletal system in previous sections dealing with classification; but at this point, we need to find out just what the skeletal system is composed of. Because of the role it plays along with the muscle system, it warrants further discussion.

The insect's exoskeleton (fig. 1-2) is the supporting framework for the outside body. The exoskeleton actually surrounds the body of an insect. This exoskeleton is composed of protein-carbohydrate material known as *chitin*, which is secreted by the cells of the *epidermis* or skin. The chitin is first a liquid when secreted and then becomes hardened, which forms the exoskeleton. It will not bend or stretch after it hardens upon secretion. The adult insect body is only capable of movement because of soft, flexible tissues *(intersegmental membranes)* between the body segments.

The muscular system. The insect's muscular system is the companion of the *skeletal* system. It allows movement and is an important characteristic of animal life. The muscular system is supported by and at-

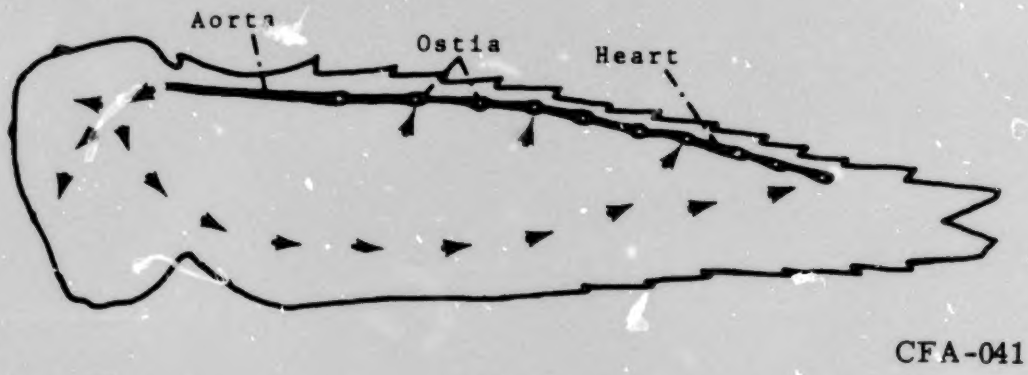


Figure 1-36. Insect circulatory system (diagrammatic).

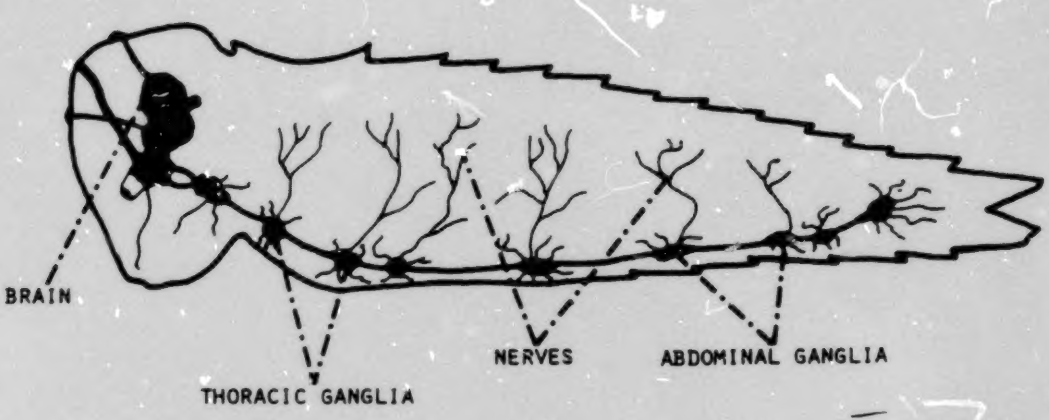

BRAIN
THORACIC GANGLIA
NERVES
ABDOMINAL GANGLIA
CFA-042

Figure 1-37. Insect nervous system (diagrammatic).

tached to the *exoskeleton* and serves to move the *appendages* of the body and operate the organs of the body which carry on the *life processes,* such as the *heart, spiracles,* and *intestines.*

Exercises (208):
Match body system functions of insects with the organs by placing the appropriate letter beside the function.

Body System Function	*Organ*
_____ 1. An insect organ that assists in removing body waste.	a. Trachea
_____ 2. An insect organ that allows air to enter the body.	b. Ganglion
_____ 3. The organ that acts as the insect's nerve center.	c. Spiracles
_____ 4. The organ that transfers air throughout the insect's body.	d. Proventriculus
_____ 5. An organ possessed by some insects that aids in digesting food.	e. Malpighian tubules
	f. Ostia

6. Complete the following statements pertaining to insect physiology:
   a. The term applied to egg-laying insects is ____________.
   b. The type of reproduction in which insects have only one sex and still have the capability of producing young is known as ____________.
   c. A substance that is first a liquid when secreted and gradually hardens and becomes the supporting framework for an insect's body is ____________.
   d. The flexible tissues located between an insect's body segments that allow movement within the body of the insect is referred to as ____________.
   e. The muscular system of insects is most dependent upon and is a companion of the ____________.
   f. The circulatory system of an insect that allows blood to circulate freely throughout the entire body cavity unenclosed is an ____________ circulatory system.

209. Identify the principal organs used in each of the five basic senses of insects.

The Senses of Insects. Insects have the same senses that are associated with man. There are the five primary senses of touch, taste, smell, hearing, and

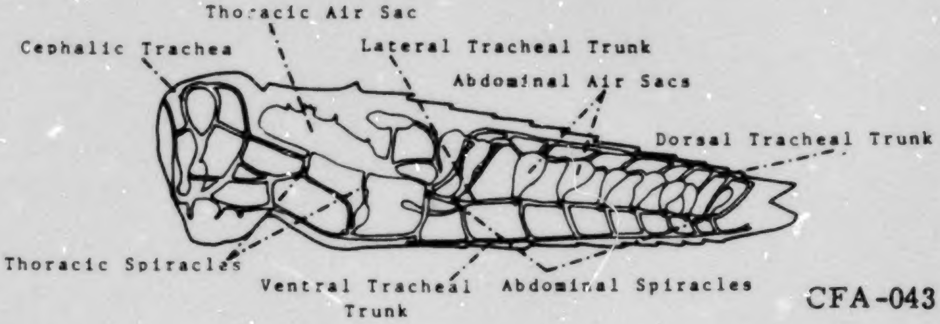

Thoracic Air Sac
Cephalic Trachea
Lateral Tracheal Trunk
Abdominal Air Sacs
Dorsal Tracheal Trunk
Thoracic Spiracles
Ventral Tracheal Trunk
Abdominal Spiracles
CFA-043

Figure 1-38. Insect respiratory system (diagrammatic).

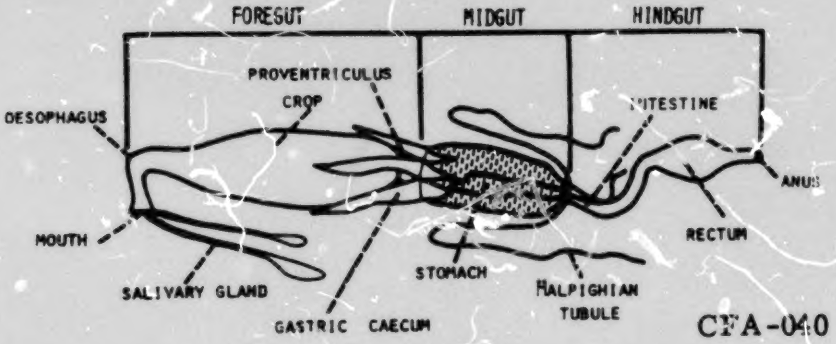


Figure 1-39. Insect digestive and excretory system (diagrammatic).

sight, and other auxiliary senses such as the sense of balance and, possibly, a sense or orientation.

Touch. Because of its hardened cuticle, the insect's skin is not sensitive to contact. The sense of touch is, therefore, served by sensory hairs occurring over most regions of the body. Figure 1-42 compares the sensory hair with an ordinary hair, illustrating the nerve which is stimulated if hairs are bent or distorted.

The antennae, or feelers, are important organs of touch. The tarsi and cerci are also sensitive to contact, and insects react very quickly to pressure on these organs.

Taste and smell. Chemical stimuli resulting from the presence of odors and substances with a taste are usually perceived by small rodlike organs projecting from the body surface. Taste is usually perceived by the mouth, the mouthparts, the palps, or the front feet. The sense of smell is localized mainly in the antennae, although palps also bear olfactory organs. The sense of smell is highly developed in insects. It is used to locate food, to find a mate, and to locate suitable places for depositing the eggs.

Hearing. The sense organs and degree of sound preception are different among insect groups. Insects do not generally respond to miscellaneous sounds but only to specific noises, such as sounds made by the opposite sex. This may be due to discrimination by the insect rather than to the lack of sound perception. Sound waves may be picked up by fine sensory hairs or by special organs such as the auditory drum that appears on the side of the abdomen or the lower part of the front legs. Flies and mosquitoes are believed to hear by means of a cuplike organ on the second antennal segment which responds to sound waves picked up by the rest of the antennae.

Sight. The principal organs of sight are the compound eyes and ocelli (fig. 1-8). Fly maggots do not have eyes but are able to detect the presence of light by means of sensitive tissue underlying the cuticle. This sense is of value to the mature maggot when it leaves its feeding site and burrows into the ground to pupate.

The compound eyes and facets are provided with nerves which transmit stimuli to the brain. Insects can perceive movements very readily, and visual powers usually vary according to the demands made on them by the habits of the insect. Laboratory tests have proved that insects are able to distinguish colors, whereas some of the higher animals, such as rats, are color-blind. The insect can neither move its eye nor focus them. However, the praying mantid can rotate its head 180° and is thought to have a good sense of vision.

There is some speculation that insects are able to reason. Although there is no proof that can substantiate this, many of their complex instinctive actions simulate the results of reasoning. For example, a wasp deposits an egg upon a spider that has been paralyzed by a deft sting in one of the main nerve centers. The spider is then buried in a small cavity in the ground and covered with earth where the egg incubates. The wasp then uses a large grain of sand as a hammer to tamp the earth over her nest.

Insect behavior appears to be a series of reflex actions or automatic responses to certain stimuli. Most insects feel secure if their feet are touching the ground or some solid object. Some bugs and beetles turned over on their backs will struggle violently to regain

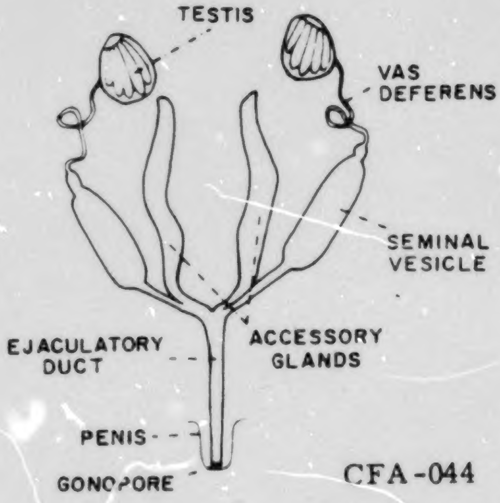


Figure 1-40. Male insect reproductive system (diagrammatic).

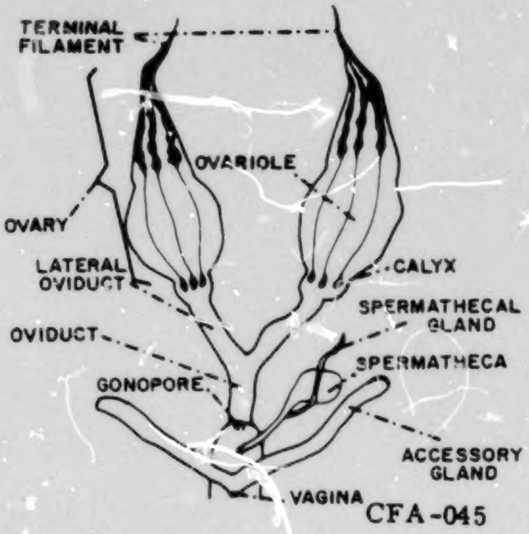


Figure 1-41. Female insect reproductive system (diagrammatic).

their feet; but their struggles cease if they are given a small object to hold. The honeybee is able to return to its hive by orienting its flight according to the declination of the sun. It performs a dance in the hive which indicates to other worker bees the location of flowers with nectar in relation to the declination of the sun and the distance from the hive. Despite these complex instinctive actions, it is believed that virtually all insect behavior arises from responses to simple stimuli such as light, heat, gravity, hunger, and smell.

The only animals that can fly are birds, bats, and insects. The ability to fly enables insects to escape many of their enemies, to locate their food, to find their mates, and to populate the earth. Insects such as the grasshopper have extremely strong muscles devoted to flight. The flight muscles of the housefly comprise 10 percent of the body weight. They activate the wings indirectly by distortion of the body wall. Housefly wings often vibrate at the rate of about 200 strokes per second. In one cycle they beat downward and forward and then turn vertically with edge uppermost and move backward. Some insects are able to hover and even to fly backward.

Exercises (209):

1. The antennae of insects provide some sense of touch, but the main sense provided by the antennae is the sense of ____________ .
2. Special hairs which occur over most regions of the insect body provide the sense of ____________ and also aid in the sense of ____________ .
3. Insects have the ability to rotate and focus their eyes. (True/False)
4. The skin of insects is a means of providing the sense of touch. (True/False)
5. Small rodlike organs which project from the body surface provide the sense of ____________ .
6. The sense of smell possessed by insects is not only used to locate food and to find a mate but it also used to locate suitable places for ____________ ____________________________ .
7. Unlike humans, insects are able to perceive movements very readily because of their ____________ eyes.
8. An ability of an insect that is shared only by birds and bats is the ability to ____________ .
9. It is believed that virtually all insect behavior arises from responses to simple ____________ .

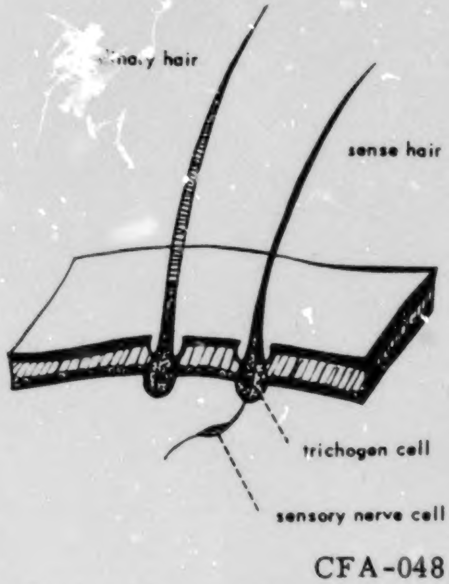


Figure 1-42. Comparison of insect ordinary hair and sensory hair.

Pest Management Planning and Coordination

AS AN AIR FORCE pest manager, you must understand the procedures for planning and coordinating effective pest management programs. Planning effective programs involves many aspects most people have not considered. Pest management programs must be effective, practical, and safe. This chapter will explain the procedures used in planning effective and safe pest management programs and will identify organizations and agencies that may be involved in pest management with whom you should coordinate.

2-1. Pest Surveys and Collection

The first step in the pest management planning phase is conducting pest surveys. Pest surveys are necessary to detect actual or potential breeding sources of pests in order to prepare recommendations for the prevention or elimination of such sources. Such surveillance involves operating light traps; locating and mapping breeding sources; and making biting and landing counts, resting station collections, population estimates, and sanitary inspections. The proper handling, packaging, and submitting of specimens to designated laboratories, in a condition which will allow identification and isolation of disease agents, is often required. This is particularly important in the detection of vector agents that might be used in biological warfare attack.

In this section you will learn the types of surveys, when and how the surveys are conducted, information gained from conducting surveys, and pest collection methods and equipment.

210. List the types of pest surveys, state the purpose for conducting pest surveys, and select the method for conducting surveys for identified pests.

Pest Surveys. After completing this objective you will understand the purpose for conducting pest surveys and recognize the types and methods for conducting these surveys.

Purpose of surveys. Surveys provide you the basis for determining whether or not management programs should be implemented; and if so, they will provide you the basis for determining the type of management program to be implemented. In addition, surveys are used for monitoring conditions that may possibly enhance pest problems, and are an effective way of evaluating pest management programs that have already been established. The importance of surveys will be better understood as the types of surveys are discussed.

Types of surveys. There are three basic types of surveys, and each type is determined primarily upon the sequence in which they are conducted.

The *original/basic* survey is the first survey to be made prior to planning any pest management program. If you happen to be the supervisor of an entomology section, this survey may be your initial survey conducted upon your arrival at a new assignment. The original/basic survey may also be the first of the year, or it may be the one that is conducted at the beginning of each job order or work order regardless if you are supervisor or not.

When conducting original/basic surveys, the following information should be obtained:

- Prevalence of beneficial and detrimental plants and animals.
- Detrimental and beneficial aspects of plants and animals.
- Conditions that are conducive to pest infestations.

Once this information is obtained, it is analyzed to determine the type of management program to be implemented, such as:

- Preventive pest management procedures.
- Safe and effective corrective pest management procedures.

Routine surveys, the second type, are used continuously to monitor pest populations and conditions that create potential pest problems. Pest problems are rarely ever eliminated; they are just arrested temporarily, which means the problems can and will most probably reoccur. Routine surveys must be accomplished frequently and should become a subconscious part of you during your travels throughout the base area.

While conducting these routine surveys you will be seeking the same information that is furnished by the survey previously discussed, and you will be searching your mind for more effective pest management techniques.

Operational surveys are conducted after pest management programs have been implemented or completed to determine program effectiveness. These surveys should always be accomplished after each job, because this is the only way you can see results of your expended efforts. They are the only way you can insure that the pests have been managed effectively. When conducting operational surveys you should also be looking for any undesirable side effects of your pest management program. If your program did not accomplish the job adequately or did have side effects, you should reevaluate the problem, study the situation more carefully, and possibly seek assistance from other sources in order to do the job more adequately.

Survey methods. Pest surveys are conducted in many ways, depending upon the pest you want to survey for and the information you are wanting to obtain. There are six basic methods for conducting most pest surveys.

Visual inspection is one method for conducting surveys. This method is especially useful for checking conditions that exist on base and areas immediately adjacent to base property. This involves checking sanitary conditions; low-lying areas that retain water; rodent runways, gnawings, and droppings; artificial containers that hold water; interior walls for cockroach and fly fecal material; structures for the presence of termites, fungi, and wood borers; and ornamental shrubs, trees, and grasses for unusual coloring or damage.

Trapping is a survey method that is used principally for collecting mosquitoes, ornamental and turf pests, and rodents. Trapping may be used to collect live specimens for conducting research to determine if they are carrying diseases, or trapping can be used for collecting specimens simply for determining identity and prevalence of certain pests.

Dipping is a method for conducting mosquito larvae surveys. Since all mosquitoes develop in water, bodies of water, small or large, can be dipped near the edges for detecting the presence of mosquitoes before they become adults.

Skimming is another survey method used for certain mosquito larvae. This method is used for detecting mosquito species that lie parallel to the water surface.

Biting and *landing count* surveys are used for sampling populations of flies and mosquitoes. When performing this type of survey, it should be conducted at the same time of day, for the same period of time, and using the same subject. The subject may be human or other animal, and in the case of nonbiting flies, dead baits may be used.

Probing is a survey method used for detecting damage caused by structural pests such as termites, fungi, and wood borers. This method can also be used for taking random samples of packaged stored foods for the detection of stored food pests.

Remember, these are not all of the pest survey methods, but these are the methods used most often. Other survey methods will be discussed later, along with discussions concerning specific pests.

Exercises (210):

1. List the three basic types of surveys.

2. State the purpose for conducting pest surveys.

3. A survey method that is used for taking random samples of stored foods in detecting stored food pests is ____________________.

4. ____________________ is a survey method used for detecting mosquito larvae that lie parallel to the water surface.

5. The survey method used for determining identity and prevalence of ornamental and turf pests is ______________.

6. The three remaining survey methods are __________ __________, __________, and __________.

211. State the purpose for collecting pests and list collection methods and equipment required for collecting identified pests.

Pest Collection. Pest collection and survey methods are most generally accomplished together; however, the degree in purpose and methods may be somewhat different.

Purpose of collecting. Specific information of medically important pests is often very useful, and in many cases most essential in determining the management technique that should be used in their control. Since there are a tremendous number of species, exact determination of a specimen frequently requires a specialist. The collection and processing techniques to be used will depend upon whether the purpose is surveillance and identification of vectors or the detection and identification of disease agents. In the latter case, live samples must be forwarded, after special processing, to an appropriate detection and identification laboratory. Bear in mind that living specimens cannot always be forwarded through the mails.

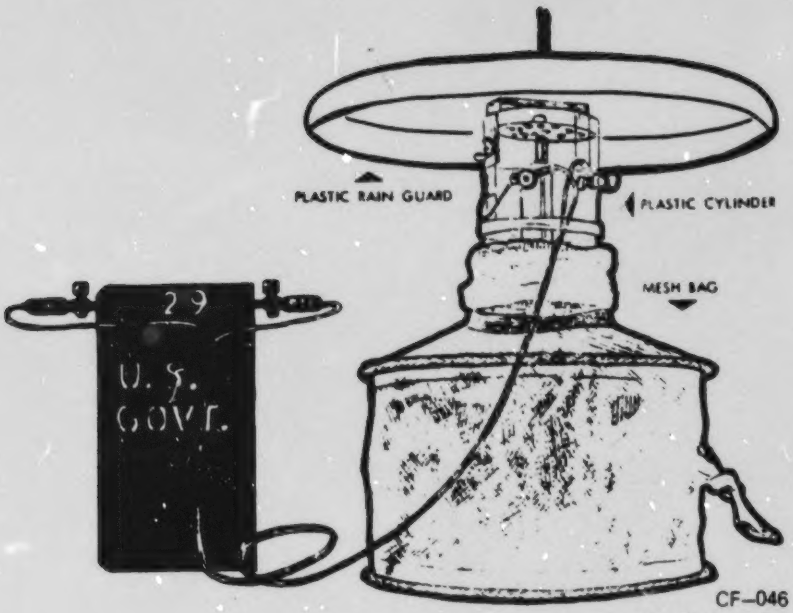


Figure 2-1. Communicable disease center miniature light trap.

Collection methods and equipment. Pest collection can be accomplished in many ways, and there is a variety of equipment that can be used; however, this text will only discuss the most common recognized methods and equipment.

Trapping is an effective way of collecting adult insects such as mosquitoes, flies, and ornamental and turf pests; and for collecting cockroaches, rodents, predatory animals, and birds. Traps may be used for collecting specimens that must be kept alive for research or for collecting specimens simply for identification, determining the quantity present within an area, or for preservation. Trapping can be accomplished by using various types of light traps such as the communicable disease center miniature light trap (fig. 2-1), black light trap (fig. 2-2) and the American light trap (figs. 2-3 and 2-4). These traps are used primarily at night so the light will attract certain night-flying insects, such as most species of mosquitoes and many ornamental and turf pests.

Cage traps of various sizes are used for collecting live specimens such as flies, mosquitoes, rodents, predatory animals, and birds. Most generally, cage traps are baited with decaying matter, live animals, or carbon dioxide to attract desired specimens. Cage traps are especially beneficial for collecting specimens that must be kept alive for research and collecting ectoparasite hosts. Figures 2-5, 2-6, 2-7, and 2-8 illustrate the various type of cage traps.

Open-mouthed jar traps can be used effectively for collecting many types of crawling pests such as cockroaches and pests active in lawns. These traps are usually baited to attract pests. Once they have entered the jar, exit is prevented by an oil coating which has been previously applied around the inner surface of the jar lip. Jar traps used in lawns should be buried with the jar lip level with the surface.

Dipping and *skimming* are two methods used in collecting mosquito larvae. This is accomplished by using a standard dipper. To aid larvae recognition, the dipper should be white porcelain, and it should be designed so that an extension handle can be easily connected. Figure 2-9 illustrates the dipper with an extension handle.

Biting and *resting* station collection methods are conducted by using aspirators and killing tubes. An aspirator is constructed from a section of plastic or glass tubing approximately 12 inches long with an inside diameter of about 3/8 inch. One end of the tube is covered with a fine wire screen and then inserted into a piece of rubber tubing 2 to 3 feet long. The aspirator is illustrated in figure 2-10. The aspirator is used for collecting small flying insects (as they are biting or resting) by placing the end of the rubber tubing in your mouth and placing the end of the glass tubing over the insect and sucking in a quick breath. Once the insect has been sucked into the glass tube, remove the glass tube and place your finger over the end. The specimen can now be emptied into a killing tube and later transferred into a pillbox. Killing tubes (fig. 2-11) are constructed from glass vials approximately 6 inches long and 1/2 inch in diameter. The bottom of the vial is filled with chopped rubberbands approximately 1 inch in depth. Then a perforated plastic disc is placed into the vial directly on top of the shredded rubber. Cotton is then placed on top of the disc, and a second perforated disc slightly larger than the vial diameter is placed on top of the cotton. The vial is charged by pouring chloroform into the vial level with the top of the rubber. The vial is stoppered with a cork. Insects are

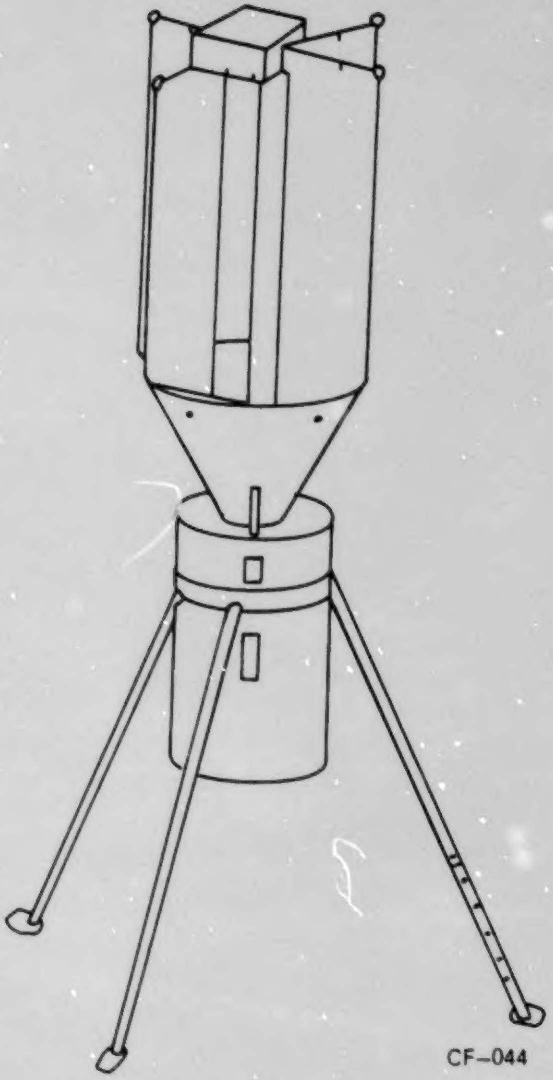


Figure 2-2. Black light trap.

collected by removing the stopper and placing the open end over the specimen as it is biting or resting. Hold the vial over the specimen until the specimen relaxes and falls into the tube, then stopper. The specimen can later be transferred to pill boxes.

Cloth drags (fig. 2-12) are used principally for collecting ticks. A piece of white flannel cloth, 1 yard wide and 1½ yards long, is attached to a rod, 1 yard long, and dragged along trails for a few yards. The cloth is then inspected and ticks that have become attached to the cloth are removed with tweezers and placed in vials of 70 percent alcohol.

Combing, brushing, swirling, and *picking* are effective methods of collecting ectoparasites (fleas, lice, ticks, and mites) from rodents, predatory animals, and domestic animals.

CAUTION: Always wear laboratory gloves while performing this collection method.

Ectoparasite hosts must be trapped in cage traps so that they will remain alive. If the host dies, ectoparasites will leave as soon as the host body temperature cools. Once the host is trapped he is removed and anesthetized (temporarily put to sleep) or killed. If combing or brushing methods are to be used, immediately pick the animal up by the tail and hold it over a pan and begin brushing or combing with downward strokes.

NOTE: The ectoparasites will not jump or crawl out of the pan because they are anesthetized also.

Once the ectoparasites have been removed, they are transferred from the pan, using a small art brush or applicator stick, to vials of alcohol. This collection method is illustrated in figures 2-13 and 2-14.

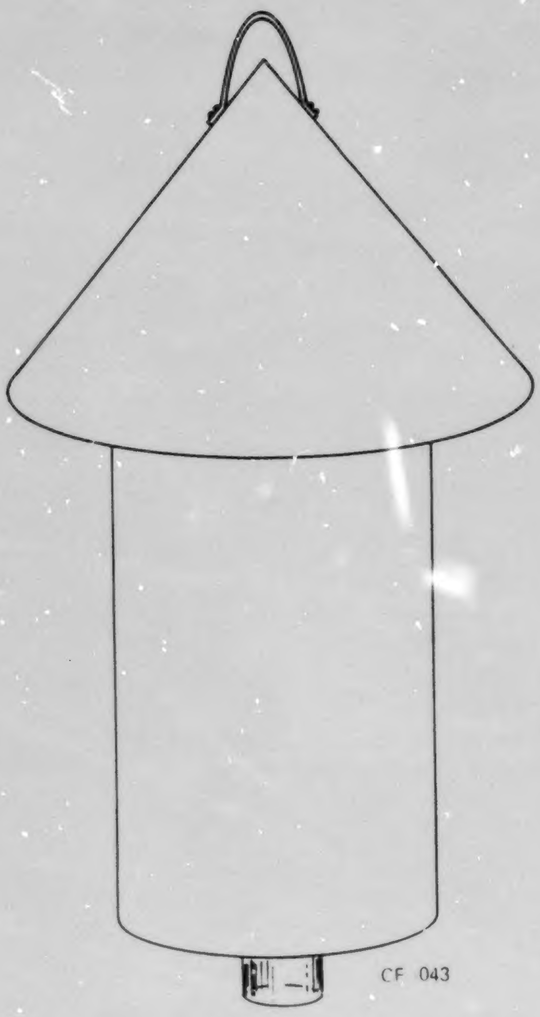


Figure 2-3. American light trap.

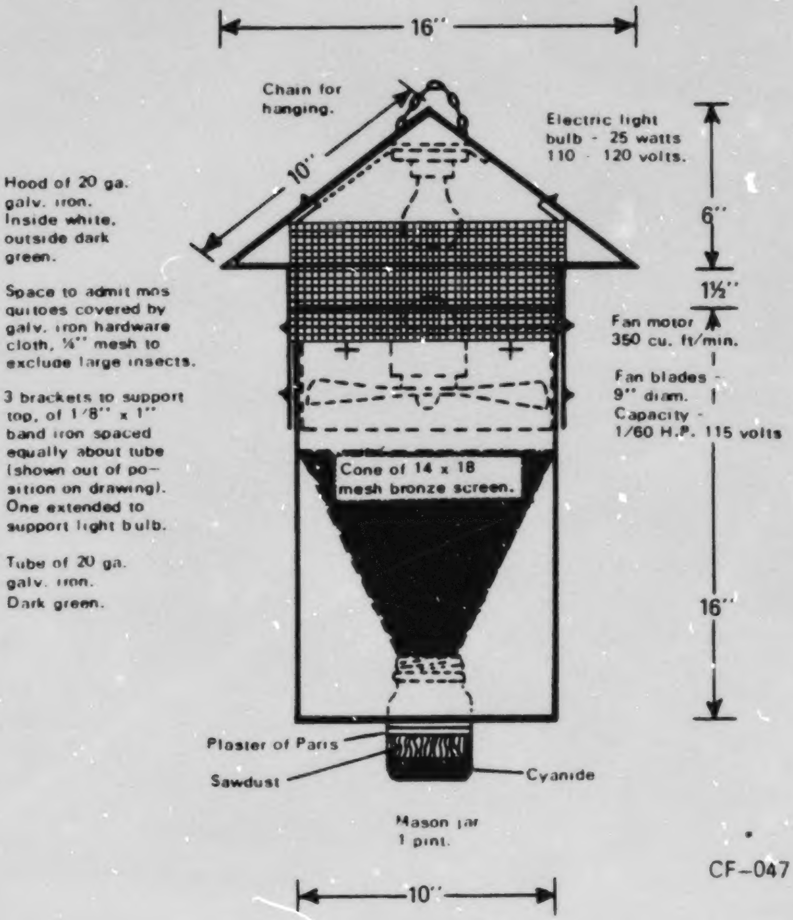

16"
Chain for hanging.
10"
Electric light bulb - 25 watts 110 - 120 volts.
Hood of 20 ga. galv. iron. Inside white, outside dark green.
6"
1½"
Space to admit mosquitoes covered by galv. iron hardware cloth, ¼" mesh to exclude large insects.
Fan motor 350 cu. ft/min.
Fan blades - 9" diam. Capacity - 1/60 H.P. 115 volts
3 brackets to support top, of 1/8" x 1" band iron spaced equally about tube (shown out of position on drawing). One extended to support light bulb.
Cone of 14 x 18 mesh bronze screen.
Tube of 20 ga. galv. iron. Dark green.
16"
Plaster of Paris
Sawdust
Cyanide
Mason jar 1 pint.
CF-047
10"

Figure 2-4. American light trap (exploded view).

Picking ectoparasites from anesthetized hosts (fig. 2-15) is accomplished by using tweezers and dropping ectoparasites into vials of alcohol. This is the only method that can be used for removing ticks and sticktight fleas.

Collecting ectoparasites by swirling is accomplished by placing the anesthetized host into a jar or tub that contains a warm soap water solution and swirling through the solution. After this has been accomplished, remove the host and slowly pour the solution through filtering paper. Then transfer ectoparasites from the filter to vials of alcohol. Figures 2-16 and 2-17 illustrate the swirling method of collection.

Digging is used primarily as a collection method for ornamental and turf pest's larvae and fly larvae. This is done by digging the soil in suspected areas. Embed the entire length of the shovel blade into the soil several times to form a circle and remove the loosened clod. Pull the clod apart (as though looking for earthworms) and inspect for grubs (beetle larvae) or maggots (fly larvae).

Exercises (211):

1. State two reasons given in the text for collecting pests.

2. State the primary purpose for using live collection methods.

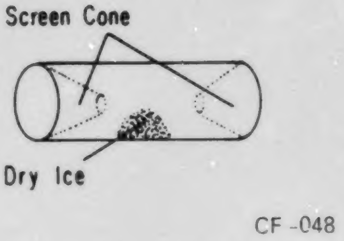
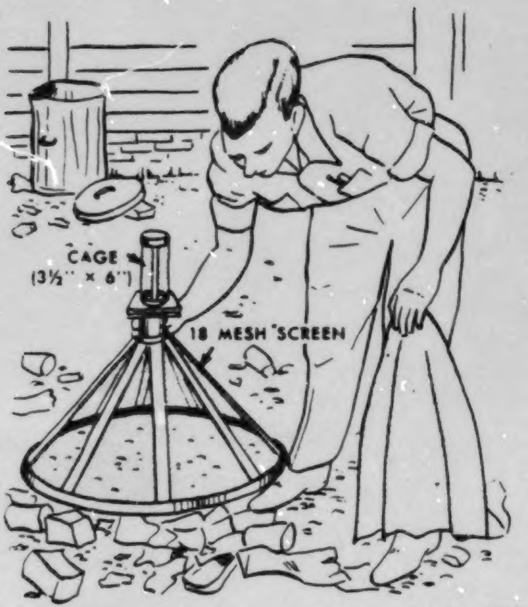

Screen Cone
Dry Ice
CF-048

Figure 2-5. Carbon dioxide trap.



CF–036

Figure 2-6. Fly cone trap.

3. Using information contained in the text, list the method or methods and equipment used for each method in collecting identified pests. NOTE: All the blanks may not have to be used.

Pest		Collection method		Collection Equipment
a. Mosquitoes (adult)	(1)		(a)	
			(b)	
			(c)	
	(2)		(a)	
			(b)	
			(c)	
	(3)		(a)	
			(b)	
			(c)	
b. Ticks	(1)		(a)	
			(b)	
			(c)	
	(2)		(a)	
			(b)	
			(c)	
	(3)		(a)	
			(b)	
			(c)	
c. Flies (adult)	(1)		(a)	
			(b)	
			(c)	
	(2)		(a)	
			(b)	
			(c)	
	(3)		(a)	
			(b)	
			(c)	
d. Mosquitoes (larvae)	(1)		(a)	
			(b)	
			(c)	
	(2)		(a)	
			(b)	
			(c)	
e. Fleas	(1)		(a)	
			(b)	
			(c)	
	(2)		(a)	
			(b)	
			(c)	
	(3)		(a)	
			(b)	
			(c)	
	(4)		(a)	
			(b)	
			(c)	

2-2. Pest Identification and Preservation

In reading Chapter 1 you learned that insects belong in the animal kingdom and that they are divided into major groups. Obviously, there are many characteristics used for placing anthropods into a particular class and order, but it doesn't stop here. You must be capable of taking a specimen and classifying it as to *family, genus,* and *specie.*

In order to fully understand this section, you must be very familiar with the illustrations provided in Chapter 1, Section 1-2 (Arthropod Morphology), so you will be able to recognize terminology applied to the various regions of the anatomy and appendages of arthopods.

General appearance, spot characters, and identification keys are the three general methods used in identifying arthropods.

The process of identification using the general appearance method simply means knowing a specimen by sight. This requires extreme knowledge and practice.

When using the spot character approach, you recognize certain characteristics that are common to a particular species; however, this method is not very reliable because other species may be very similar. This approach may be used in placing a specimen in its *order.*

This section describes the types of keys used in the process of identification, use of identification keys, use and maintenance of microscopes, and methods for preserving and maintaining specimens.

212. Identify the two types of identification keys, and provided with sets of identification keys, list the steps that must be followed in the identification of specified pests.

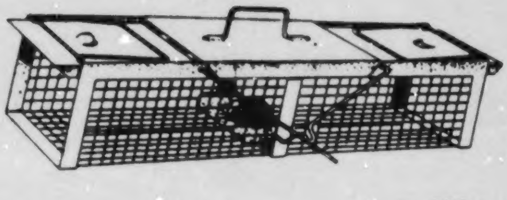


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Figure 2-7. Live animal trap.

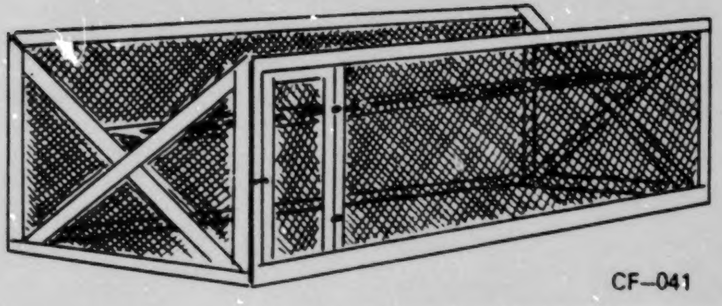


Figure 2-8. V-drop bird trap.

Identification Keys. Accurate pest identification can be accomplished only if specimens have been collected carefully and undamaged; in addition, you must be very knowledgeable of arthropod structures and you must have complete sets of identification keys. This objective is devoted to making you aware of common types of identification keys, explaining their use, and enabling you to use them properly.

Types and uses of identification keys. In most situations, identification with *family, genus,* and *specie* requires the use of a microscope (discussed later), a good set of keys, and a specimen that is properly mounted and in very good condition.

After you have had experience in identification, you will most likely establish a preference as to the type of key most suitable for your use. There are two basic types of keys commonly used *(dichotomous or couplet* and *pictorial),* and each has its own merits. Identification keys work by using a process of elimination in which the number of possibilities is gradually reduced. When making identification, you should keep in mind that a key does not positively prove anything; it only suggest possibilities.

Dichotomous or couplet keys are so named because they provide two alternatives from which to choose. Using dichotomous or couplet keys (both are same type), you must begin with couplet 1, which will give you two choices as illustrated in example 1. In this example you must make a choice between the number and type of wings the specimen has.

Example 1: Couplet 1

1. Two pairs of membranous wings ------------------------ 2

Only one pair of membranous wings, the other pair being either hardened into wing cases, or absent --------------- 29

In this situation, assume that your specimen has two pairs of membranous wings, so couplet 1 tells you to proceed to couplet 2. If the second choice had been correct then you would have proceeded to couplet 29, skipping couplets 2 through 28.

To continue the identification process using dichotomous keys, another example is provided using couplet 2. Observe example 2, couplet 2, and study its relation to example 1, couplet 1.

Example 2: Couplet 2

2. Forewings and hindwings alike ------------------------ 3

Forewings and hindwings different -------------------- 18

Continuing the case situation, assume that your specimen has forewings and hindwings alike. From information contained in example 2, couplet 2, you now know that you should proceed to couplet 3, since your specimen does not have different forewings and hindwings. This same process of elimination between two choices continues until you reach the final identification.

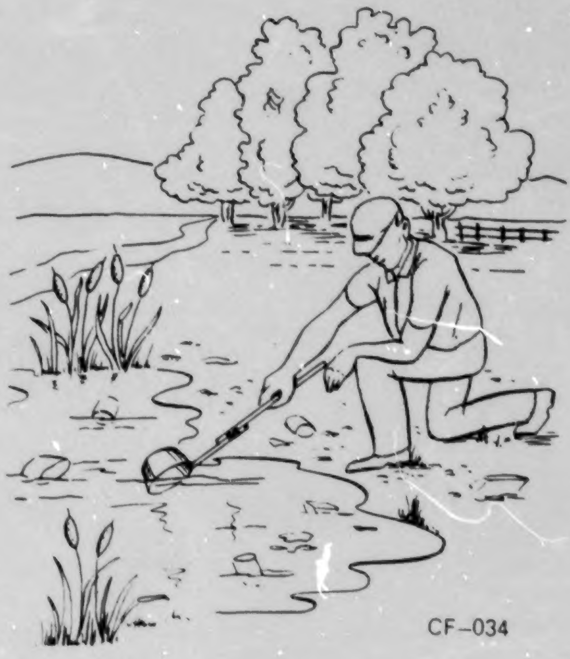


Figure 2-9. Dipper for collecting mosquito larvae.

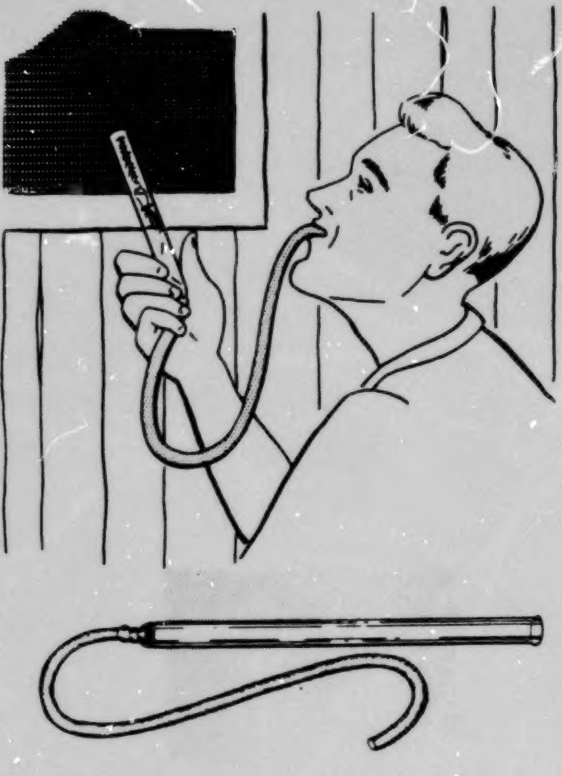


Figure 2-10. Aspirator for collecting adult mosquitoes.

To recognize when identification is complete, another example is provided. Up to this point, you have identified your specimen from couplets 1 and 2 as having two pairs of membranous wings and both pairs of wings are alike. Referring to your case situation, assume that after reading couplet 3, it was determined that you must proceed to couplet 35. Finding couplet 35, illustrated in example 3, you find a different situation.

Example 3: Couplet 35

35. Abdomen with foreceps ---------------------- Earwig

Abdomen without foreceps --------------------- Beetle

Assuming that your specimen has an abdomen with foreceps, you realize that it is an earwig. Identification is now complete. However, if your specimen had an abdomen without forceps it would have been identified as being a beetle according to the example. Naturally, there are many beetle species, so you would have to obtain identification keys that pertain to the appropriate *order*, which is *Coleoptera*.

Now that you have seen how dichotomous keys are used, take a look at another type of identification key.

Pictorial keys are keys that provide the identifier with illustrative pictures that show specific points of interest and comparisons of various pests. This type of key is preferred by many individuals and is probably more simple to use by the less experienced.

At the top of each pictorial key there are two or more statements with accompanying illustrations that show exactly what the statements are referring to; of course, only one of the statements will apply to the specimen being identified. A typical pictorial key is illustrated in figure 2-18; however, this key has been modified with the addition of capital letters at the top and small letters on the left side to reflect a grid situation. This modification is designed to better illustrate its use.

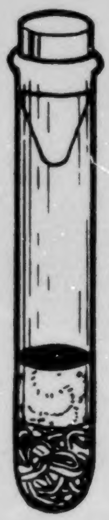
Before you begin to utilize the pictorial key provided in figure 2-18, read case situation 2-1. This case situation provides you background information and it describes the specimen to be identified.

Case Situation 2-1

The specimen you are identifying has already been identified with its *order*, and it has been determined that the specimen is a fly. The next step is to determine the *genus* and *specie* of the fly. Your specimen has a dull thorax and a shiny abdomen as observed through the microscope.

In order to identify your fly specimen, refer to figure 2-18 and read each of the three statements provided across the top directly above each of the three files. When you have found the statement that describes your specimen, the identification of your specimen should be complete because square B-a identifies your specimen as to *genus* and *specie*.

Now, using case situation 2-2 and figure 2-18, test your skill in using the pictorial key once more.



CF–039

Figure 2-11. Killing tube.

1/2 2

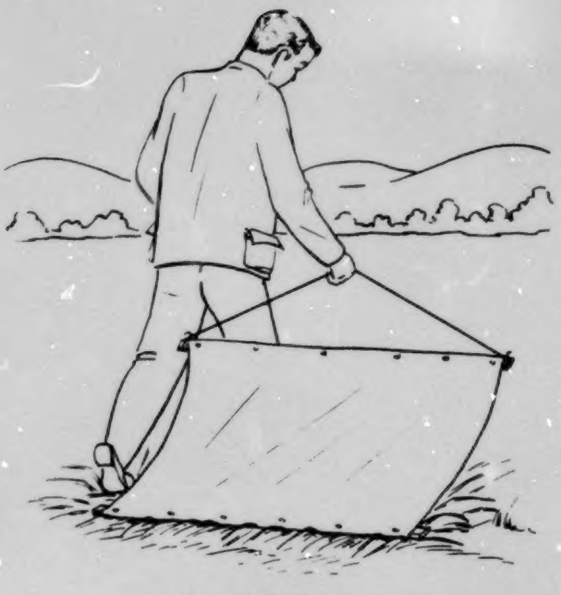


Figure 2-12. Tick drag.

Case Situation 2-2

As in case situation 2-1 your specimen is a fly, and as you view through the microscope you see that it has the following characteristics: dull thorax and dull abdomen; medium size (about 1/4 inch long) 4 distinct thoracic stripes; sides of abdomen pale, erect when resting, thorax without pale spots.

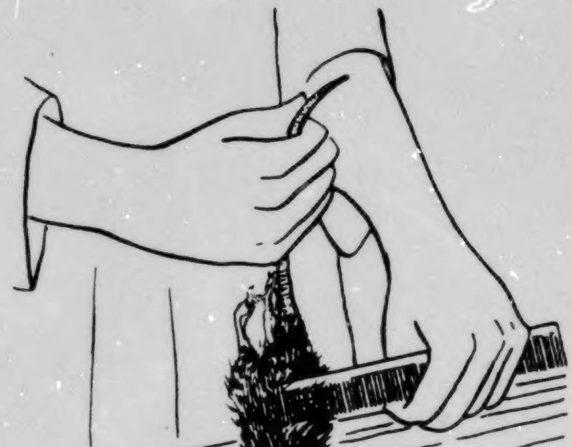


Figure 2-13. Combing for ectoparasites.

To identify the specimen as described in case situation 2-2 and using the pictorial key illustrated in figure 2-18, you should begin at the top. Reading across the top, the fly and statement you select should be square A-a because your specimen has a dull thorax and a dull abdomen.

Now, as you can see, there is a line extending down and across from square A-a which means identification is not complete and you have three more choices to select from.

Reading the statements and viewing the illustrations across row b you find that square B-b best matches your specimen because it is medium size (about 1/4 inch long) and has four distinct thoracic stripes. Now, you may say wait a minute; square B-b describes the specimen as having four thoracic stripes that are often indistinct, but my specimen has four distinct thoracic stripes! You are correct, but in comparing your specimen with the other two choices you will find that it matches square B-b better because it is not a small fly with four indistinct stripes and it is not a large fly with only three distinct thoracic stripes.

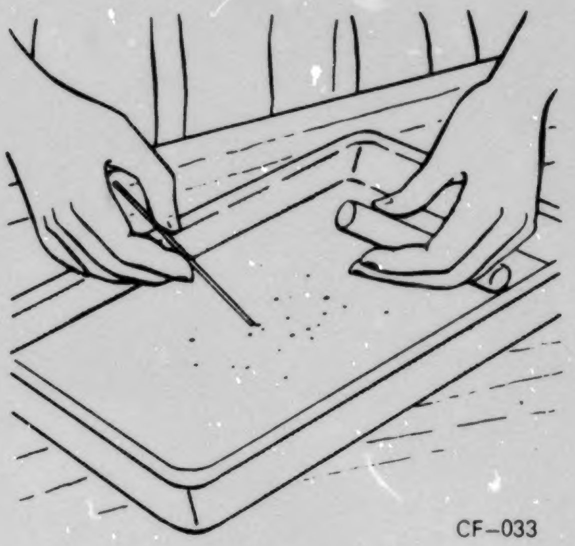


Figure 2-14. Transferring ectoparasites.

Again, there is a line that extends from down from square B-b and across to the left and right. As you can see, there are three more choices to select from.

You should follow the same procedures as before by reading the statements and viewing the illustrations provided in row c of figure 2-18. Square A-c describes your specimen prefectly; so, identification is complete and you now know that it is a *Musca domestica* (scientific name), or housefly (common name). If you will notice, there are no lines extending down from either of the three choices in row c, so your specimen would have had to have been one of the three, or it would have indicated that you had made an error previously.

In specimen identification, people commonly make one of two mistakes, the first being overly cautious

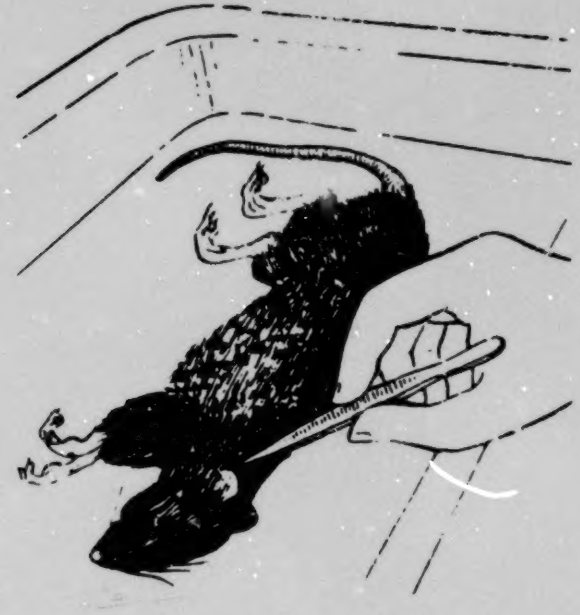


Figure 2-15. Picking ectoparasites.

(taking every word literally), and the second is refusing to go on if the specimen does not agree with the choice made. Remember, insects and other arthropods have their individualities just as people do.

If you happen to arrive at a point in which you cannot decide which of the alternatives is correct, don't give up! First, consider if it is neither; for instance, if the alternatives describe wing structures and youir specimen has no wings, you have probably arrived at a wrong point in the key, or else the specimen is one that is not provided for by the key. Second, if there is more than one alternative which could be considered correct, try each alternative until you have made your decision. By using this process, you can normally get back on the right track.

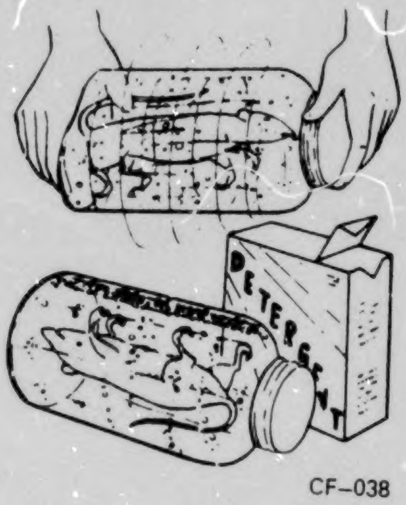


Figure 2-16. Swirling for ectoparasites.

Dichotomus and pictorial keys of important arthropods are provided in Appendix A of this volume.

Exercises (212):

1. The two types of identification keys commonly used are ______________ and ______________.
2. An identification key that provides two statements from which to choose is the ____________ key.
3. An identification key that illustrates certain identifying characteristics and provides two or more choices is a ______________ key.

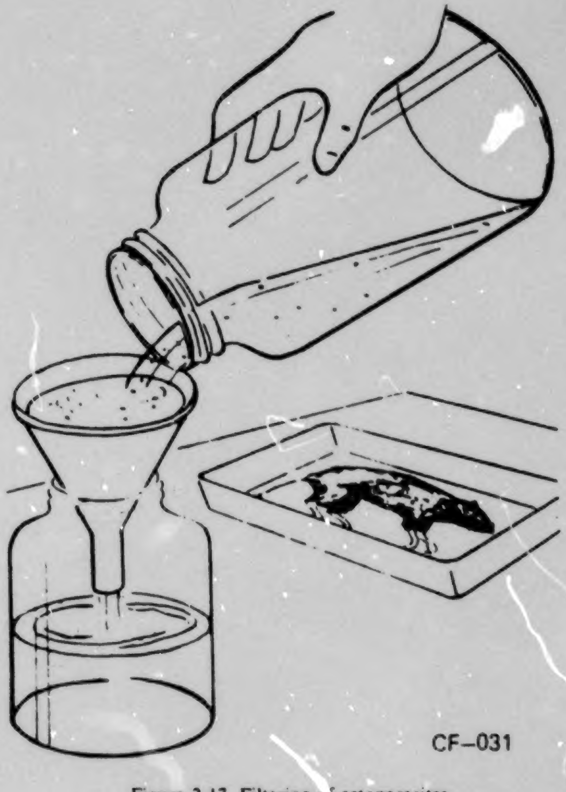


Figure 2-17. Filtering of ectoparasites.

4. Using Appendix A, "Arthropods of Public Health Importance: Key To Common Classes and Orders," and information contained in this objective, identify each of the arthropods described below with its order and common name, and list each step consecutively that is used in the identification process as per example.

Exercise Example: An arthropod that is described as having three pairs of walking legs, wings present and well developed, one pair of membranous wings without scales is identified to

(1) the Order Diptera ,

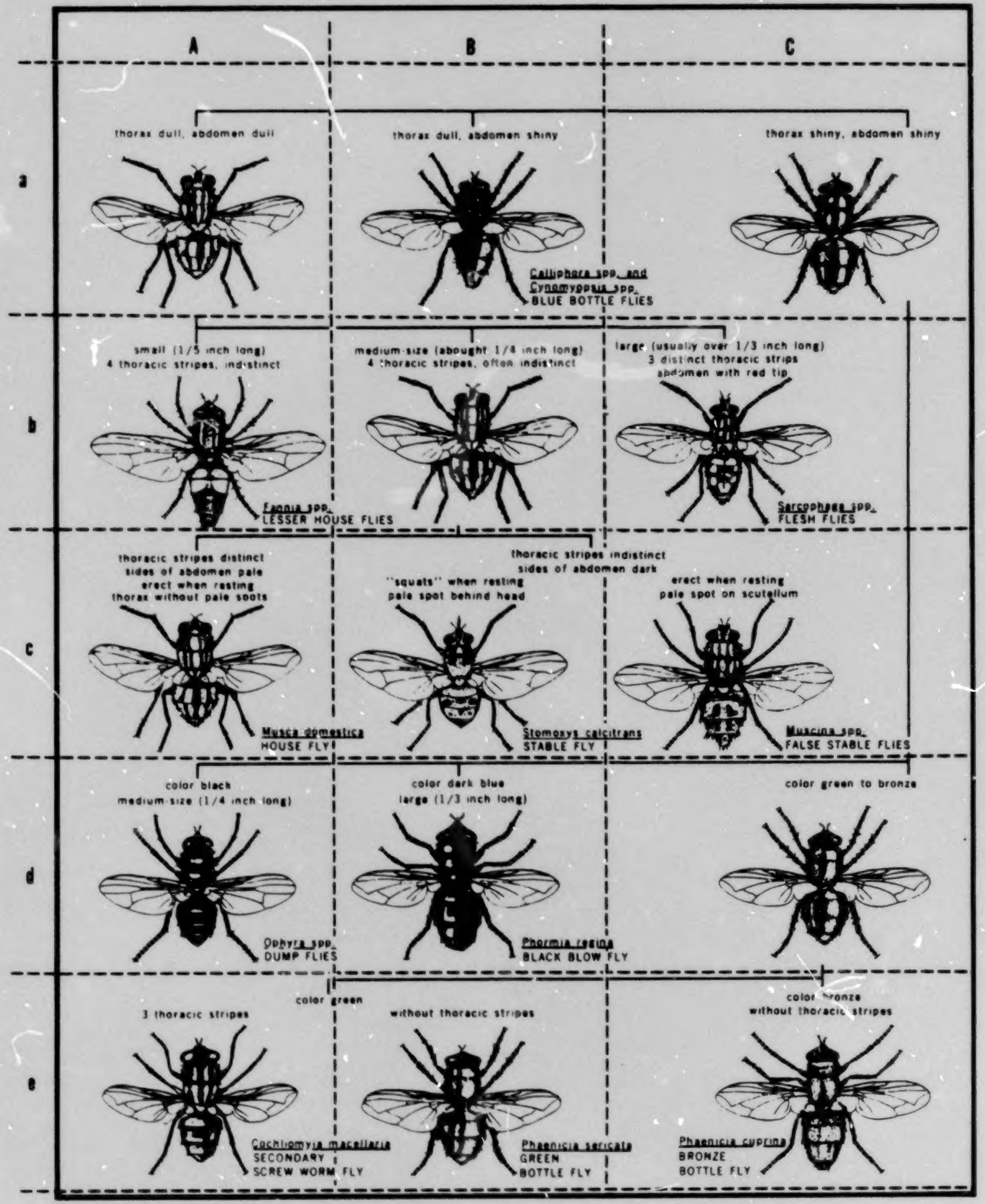

A
B
C
a
b
c
d
e
thorax dull, abdomen dull
thorax dull, abdomen shiny
thorax shiny, abdomen shiny
Calliphora spp. and
Cynomyopsis spp.
BLUE BOTTLE FLIES
small (1/5 inch long)
4 thoracic stripes, indistinct
medium-size (abought 1/4 inch long)
4 thoracic stripes, often indistinct
large (usually over 1/3 inch long)
3 distinct thoracic strips
abdomen with red tip
Fannia spp.
LESSER HOUSE FLIES
Sarcophaga spp.
FLESH FLIES
thoracic stripes distinct
sides of abdomen pale
erect when resting
thorax without pale spots
thoracic stripes indistinct
sides of abdomen dark
"squats" when resting
pale spot behind head
erect when resting
pale spot on scutellum
Musca domestica
HOUSE FLY
Stomoxys calcitrans
STABLE FLY
Muscina spp.
FALSE STABLE FLIES
color black
medium-size (1/4 inch long)
color dark blue
large (1/3 inch long)
color green to bronze
Ophyra spp.
DUMP FLIES
Phormia regina
BLACK BLOW FLY
color green
3 thoracic stripes
without thoracic stripes
color bronze
without thoracic stripes
Cochliomyia macellaria
SECONDARY
SCREW WORM FLY
Phaenicia sericata
GREEN
BOTTLE FLY
Phaenicia cuprina
BRONZE
BOTTLE FLY
CFA 078

Figure 2-18. Typical pictoral key.

(2) with the common name of fly ,
and the steps used in identification are 1 , 2 , 3 , 4 , and 5 .

a. An arthropod described as having three pairs of walking legs, chewing mouthparts, two pairs of well-developed wings with the front pair of wings being leathery with distinct veins and serving as covers for the second pair is identified to

(1) the Order ______________ ,

(2) with the common name of ______________ ,

(3) and the steps used in identification are

________, ________, ________, ________,
and ________.

b. An arthropod described as having four pairs of walking legs, a well-developed abdomen that is not distinctly separated, body with very little or no hair, and hallers organ is identified to
(1) the Order ________,
(2) with the common name of ________,
(3) and the steps used in identification are ________, ________, ________, ________,
and ________.

213. Given problem situations concerning microscope use, identify the proper corrective action and state the methods for maintaining microscopes.

Use and Maintenance of Microscopes. Most arthropods cannot be identified to *genus* and *specie* without the aid of a microscope. Each pest management section should have a microscope to identify pests common to the area and to monitor possible disease vectors and economic pests collected. Microscopes are also essential in calibrating certain types of pesticide dispersal equipment and conducting on-the-job training for pest identification. However, microscopes are of no use unless you know how to use and maintain them properly, which is the basis for this objective.

Microscope focusing. Microscope focusing methods will vary with the type of microscope used and the manufacturer. For this reason, a specific type must be identified so that focusing techniques can be discussed. The microscope discussed in this objective is one that is authorized for pest management sections and is Federally stock listed. This microscope is a binocular type with zoom focusing ability which is most suitable for viewing solid objects such as arthropod specimens. Figure 2-19 illustrates the binocular zoom focusing microscope with identified external parts.

In order to focus the binocular zoom microscope follow these procedures:

(1) Place the object to be viewed on the stage plate and insert a pair of eyepieces in the eyepiece adapters.

NOTE: If you wear corrective glasses, insure that glasses are worn while using the microscope.

(2) Direct light on the subject being viewed by adjusting the mirror beneath the stage plate or by using other illumination devices which are available as accessories.

(3) Adjust the eyepiece adapters to the proper width for your eyes so both fields are viewed as one. Proper width can be checked by closing one eye and then the other, with both fields being visible separately without moving the head.

(4) Set the magnification knob to the highest power.

(5) Using only the right eye and right eyepiece, focus on a flat-surfaced object that is centered on the stage and adjust the focusing knob until the image is sharp.

(6) Now, reset the magnification knob to the lowest power.

(7) Using the left eye and left eyepiece, adjust the eyepiece focusing ring clockwise or counterclockwise until the image is sharp.

NOTE: This should be accomplished without disturbing the focusing knob.

If these microscope focusing procedures are carefully followed, the magnification may be set at any value within its range without having to refocus. When changing specimens, only slight readjustments of the focusing knob are required in order to maintain sharp image focus.

NOTE: Always insure that the microscope is focused to suit the right eye first and then focused to the left eye using the eyepiece adjusting ring.

The magnification knob (located on top of the microscope) allows you to change the power to provide the best magnification for each specimen at lower power and to concentrate on a particular detail of the specimen by increasing the power.

Microscope maintenance. Maintaining microscopes is a simple process if you remember one basic point. *Always cover the microscope when not in use.* Since cleaning is practically all that is required in maintaining microscopes, cleaning techniques will be discussed first.

a. Clean external surfaces of eyepieces and bottom surface of the pod by blowing with a syringe, or with a moist cotton swab on a stick.

b. Keep eyepieces in place at all times to prevent dust settling on the eyepiece dust shields. If the eyepiece dust shields do require cleaning, clean them in the same manner as the external surfaces of the eyepieces.

c. Use a cotton swab moistened with a soap or detergent solution to remove body oil smears from external surfaces of eyepiece lenses or glass stage plate, and dry with a dry cotton swab.

d. Clean the focusing slide occasionally with a solvent such as xylol or alcohol.

e. Clean rack teeth occasionally with a small stiff brush.

f. Lubrication is required only after the focusing slide has been cleaned. Lubricate the focusing slide by applying a light coating of petroleum jelly.

g. Adjusting the tension of the focusing mechanism is the only time mechanical maintenance should be performed on the microscope unless you are an experienced microscope repairman. To adjust focusing tension, turn two allen-head screws (located slightly above the center line of the focusing knobs) clockwise or counterclockwise, depending if more or less tension is desired. NOTE: Uniform adjustment of the two screws is recommended.

Microscopes are only effective if the user knows how to use it and maintains it properly. When moving the microscope, always use both hands and handle it

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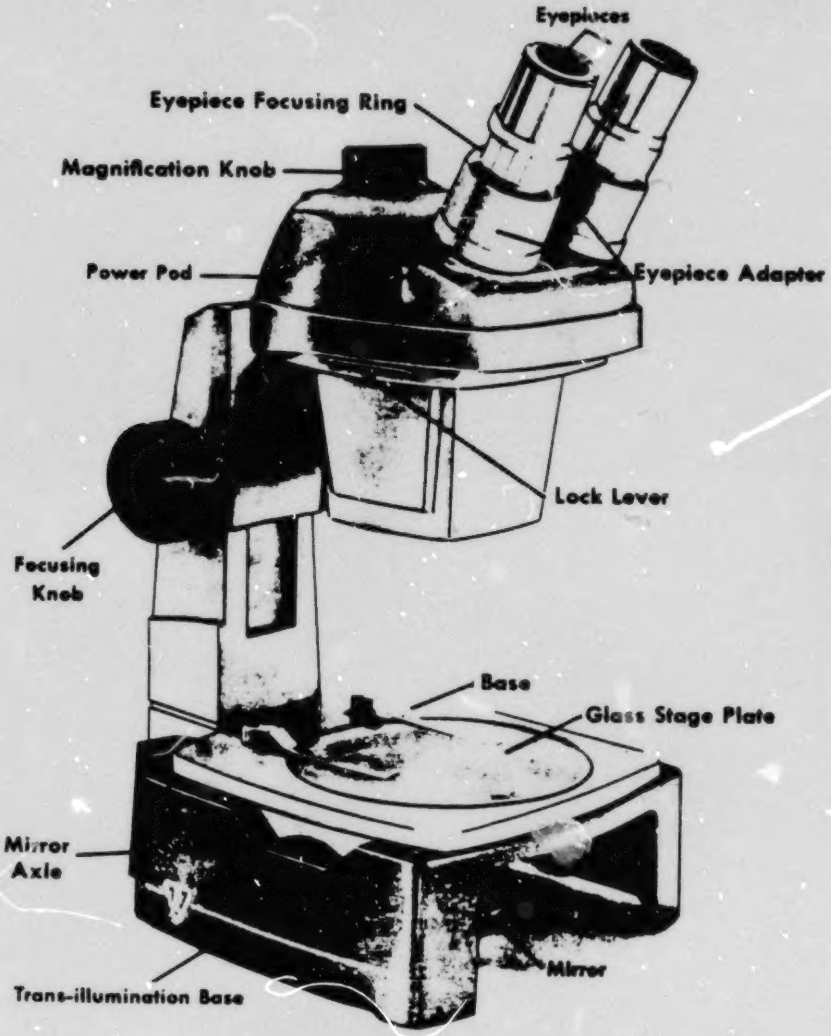
Eyepieces
Eyepiece Focusing Ring
Magnification Knob
Power Pod
Eyepiece Adapter
Lock Lever
Focusing Knob
Base
Glass Stage Plate
Mirror Axle
Trans-illumination Base
Mirror
CF–042

Figure 2-19. Binocular microscope (identified external parts).

with care because it is a fragile instrument and very expensive.

Exercises (213):

1. While viewing an object through a microscope, it appears as a double vision. Identify the corrective action to be taken.

2. While viewing an object through a microscope, it appears clear and sharp, indicating good focus. You then change objects and the vision is blurred. Identify the action that you have failed to take.

3. Identify the action to be taken prior to making microscope adjustments other than adjusting the eyepiece adapters.

4. The microscope is always focused to suit which eye first?

5. State the action required to remove grease smears from external surfaces of eyepiece lenses.

6. To remove dust from external surfaces of eyepieces you would use a detergent solution. (True/False)

214. Point out techniques, materials, and equipment required for preserving specimens dry.

Preserving Specimens Dry. In order to maintain a display of pests common to the area, there are certain techniques that you should learn. Pest specimen displays that you prepare should be prepared in a manner that you will be very proud to display. These displays are kept in entomology sections to allow interested persons to become familiar with pests common to the area, and they are often used for display in base open house ceremonies, Boy and Girl Scout tours, student tours, and county fairs.

There are four basic methods used in displaying pest specimens and each method requires certain techniques, supplies, and equipment. Each of the four methods will be discussed individually.

Preserving specimens dry is probably the most common method for preserving specimens and is generally the most useful for insects that have strongly chitinized exoskeletons because they can be dried naturally without offensive decay and discoloration.

Specimens that are to be preserved dry should be pinned while they are still fresh to allow easy manipulation of various appendages, thus reducing the chance of breakage. Specimens that have become dried are very hard and brittle and should never be touched other than by handling the mount.

To delay hardening, specimens can be placed in containers of ethyl acetate or laurel leaf vapors. You may find that this is not always advisable because over a period of time it may cause discoloration or a mushy effect. Other methods for keeping the specimens soft include keeping them in a tin container with green leaves or moistened blotting paper, but this may lead to the specimens' becoming molded.

If you desire to dry-preserve specimens that have a large amount of body fluids, the fluid should be drained from the abdomen immediately after the specimen has died. The best method to use in this situation is to cut off the abdomen at the base, lay it on a flat surface, and squeeze the fluid out by rolling a small round object from abdomen tip toward the cutoff portion. This must be done with great care to prevent damage to the abdomen section. Removing the abdomen from specimens that are bulky is not required at all times. The fluids from some specimens may be extracted simply by gently rolling a round object over the abdomen, beginning at the base and rolling toward the tip.

Cleaning the specimens is required at times, expecially the bulky ones that have been drained of body fluids; however, it is best to avoid cleaning whenever possible because this may cause discoloration. Dust can be removed by using a small camel's-hair brush; but remember to use gentle strokes to avoid breakage of appendages and scratches. Cleaning specimens that are very fragile or dry and rigid can be accomplished by immersing them in a synthetic detergent and water solution. Specimens that have become greasy from fatty material that has oozed out can be cleaned by using an organic solvent such as ethyl acetate, benzene, or ether.

Bulky and fleshy specimens that you have had to drain must be returned to the original shape. This can be done by blowing air into them, using a small pipette; or if it is a large area, it can be stuffed with cotton wool that has been moistened with ethyl acetate or phenol. After this has been done, the specimen must be mended by using mending cement. This will involve reattaching the inflated or stuffed abdomen if it has been removed for draining purposes.

Now that you have your specimen soft, clean, and repaired, it is prepared for setting. Setting a specimen correctly is probably the most difficult and rewarding part in preparing your specimen displays. The specimen must be set so that is it appealing to the eye and in a manner so important appendages can be viewed with least difficulty. Once you have arranged it in the position desired you must let it dry. Setting specimens require the use of setting boards. These boards may be purchased or constructed in the section. Setting boards are designed to allow adjustment of the sides to increase or decrease the width of the groove, depending upon the thickness of the specimen abdomen. The sides of the board should be covered with a layer of cork or balsa wood to allow ease in pinning. A typical setting board is illustrated in figure 2-20.

If you desire to dry-preserve specimens that are soft bodied without draining the body fluids, this can be achieved by preserving them in a solid state. This technique is much slower than the conventional way because each phase requires a certain amount of time; however, it is a very good technique to use for larvae specimens. Dry preserving in the solid state is accomplished by placing fresh larvae into a solution that contains 95 percent alcohol. The larvae must remain in this solution for at least 1 week; the larger the specimen the more time required. Following the week's (minimum) stay in the first solution, the larvae are then transferred to a pure alcohol solution and

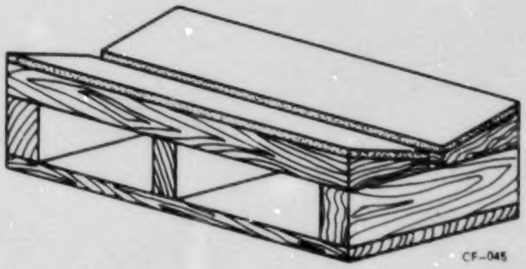

Figure 2-20. Typical setting board.

must remain in this solution for 24 hours. The larvae are then transferred to a fresh solution of pure alcohol two more times for a period of 24 hours each. After these phases have been completed, the larvae tissues should be completely dehydrated; however, preservation is not complete.

Reabsorption of moisture must be prevented. This is done by transferring the larvae into a solution containing one part of xylol to 2 parts of pure alcohol for 1 day,then transferred again to a solution of 2 parts of xylol to 1 part of pure alcohol for 1 day. The larvae are then transferred to pure xylol, kept there 1 day, and removed and blotted dry. The specimens are not ready to be pinned.

Larvae that have become hardened or dry can also be dry-preserved in a solid state, but they must be resoftened first. Resoftening can be done by placing the specimens in a solution of 2 percent caustic potash or a strong solution of synthetic detergent for a period of 2 days. Larvae are then transferred successively to solutions of 40 percent, 70 percent, 80 percent, and 95 percent for a period of 1 week minimum in each solution. After this, the larvae must be treated to prevent reabsorption of moisture in the same way as previously explained for fresh larvae.

Pinning dry-preserved specimens can be done in four ways. *Direct pinning* is a method that can be used for specimens that have tough cuticles or integurments and are not very small. Pins that are used for direct pinning are called "continental pins" and are generally long, thin, and sharp. *Staging* is a method that involves pinning a relatively small specimen to polyporous. The polyporous serves as the stage and is supported by "English pins." However, the pins used for attaching the specimens to the stages are "points." Points are very thin and short and may be used by inserting the pin through the specimen and into the polyporous stage or by gumming the specimen to the blunt end. *Carding* is a term used when specimens are gummed directly to a piece of stiff white cardboard that is rectangular in shape and is supported by English pins. This method is quite adequate for displaying small beetles. *Pointing* is the best method for mounting the very small dry-preserved specimens. Points are made from thin white cardboard and are cut into small triangular pieces. These pieces may be pointed or blunt, depending upon the specimen being mounted and your preference. Points can even be turned up or down at the tip and the specimen gummed to the side if you desire.

Now that you have your dry-preserved specimen pinned, it is time to discuss specimen labeling.

Specimen labeling is very important because each specimen should be labeled as to where, when, and how the collection was made, the collector's name, the scientific name of the specimen, the name of the scientist who first described the *specie,* and the date determination of the *specie* was made.

Labels are made from thin white card material such as index cards, and every label should be rectangular shape and have almost the same dimensions. Each dry-preserved specimen should have two labels pinned beneath the specimen. The lower label should rest on top of the surface to which the specimen is pinned and should contain the scientific name of the specimen, the name of the scientist (or author), and the date it was first described. The second label should be spaced in the middle between the specimen and the lower label and should contain information as to where, when, and how the specimen was collected, and the name of the collector. labeling techniques are illustrated in figure 2-21. Be as specific as possible when describing the location where the specimen was collected. It is not advisable to use initials because they can lead to confusion. Print information on labels using pencil or India ink.

Storage of dry-preserved specimens is important in preventing specimen damage and enhancing displays. Specimens can be stored in almost anything from cigar boxes to specially designed specimen trays. However, specimens should be separated into specific orders, protected from pests that attack preserved specimens, and arranged for easy viewing. Storage boxes should be durable, lined with cork on the bottom for ease in pinning, and capable of holding paradichlorobenzene or naphthalene to ward off pests that feed on specimens. Specimens should be stored in an area with minimum humidity when possible.

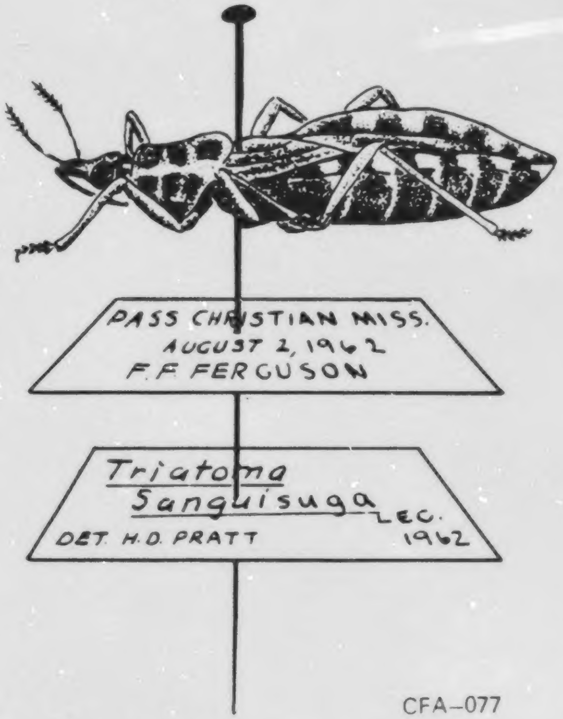

Figure 2-21. Labeling technique for dry specimen.

Exercises (214):

1. What is the primary purpose for collecting, preserving, and maintaining pest specimens within a pest management section?

2. The most common method used in preserving specimens for display is the ____________ method.

3. Specimens that have become hardened can be resoftened by using a solution of ____________ or a strong solution of ____________.

4. State the best method for draining body fluids from specimens that are being preserved dry.

5. Dust can be removed from dry specimens by using a ____________.

6. List three organic solvents that can be used for cleaning greasy specimens.

7. List the four methods used in pinning dry specimens.

8. List the information that is provided by the lower label contained on dry specimens.

9. Dry-preserved specimens can be protected in storage from pests that attack preserved specimens by using ____________ or ____________.

215. Specify techniques and materials required for preserving specimens in spirits.

Preserving Specimens in Spirits. This method is probably considered to be the best for preserving specimens that are soft bodies such as larvae, nymphs, and some adult *species*. Specimens may be preserved in spirits of ethyl alcohol, Pampel's fluid, and chloral hydrate. Specimens are normally stored in small laboratory test tubes with rounded bottoms. Several small specimens of the same *specie* collected at the same point and time can be stored in the same tube, but larger specimens may require individual tubes for storage. Labels for spirit-preserved specimens are constructed by cutting long thin strips of white card material. Card strips should be approximately 1 inch shorter than the length of the tube and should be wide enough to allow sufficient bend in the card when it is placed inside the tube. Only one strip is required, but it should contain the same type of information as the two labels do in the dry preservation method. Labels that are printed in pencil are most desirable and durable because ink will have a tendency to smear when placed in the spirits. Once the specimens and labels have been placed in the spirits, the tube is sealed with a spirit-resistant rubber stopper. Tubes are then stored in specially designed double-layered trays that have small round holes cut out of the top layer for inserting the tube, or they can be stored in a glass jar to allow easy viewing. Spirit-preserved specimens should be stored in a cool, dark area away from all sources of heat to prevent accidental fires and evaporation.

Exercises (215):

1. Preserving specimens in spirits is considered to be the best preserving method for ____________ specimens.

2. The spirits most generally used in preserving specimens are ____________, ____________, and ____________.

3. State the storage precautions that must be observed for spirit-preserved specimens.

4. Information provided on labels to be used in spirits is printed in pencil to prevent ____________.

216. Point out techniques and materials required for preserving specimens in plastic.

Preserving Specimens in Plastic. This method of preserving specimens is a relatively new concept and is very appropriate for large, bulky specimens. When properly performed, this preservation method makes very attractive displays, and they can be handled without damage to the specimen; however, care must be taken to avoid dropping because the block will break. There are several techniques that can be used in preserving specimens in plastic, depending upon how the specimen was originally preserved. The techniques which will be discussed in this section are based upon the specimen being fresh or originally dry-preserved. Specimens that are to be preserved in plastic should be presoaked in uncatalyzed resin for approximately 24 hours to remove air bubbles from the surface and insides of the specimens. Insure that the specimen is completely immersed (weighted down if necessary) and the container is covered. After the specimen has soaked for the required period of time, select a glass or smooth metal container that is appropriate for the size of specimen being preserved. After you have selected the container best suited to be used as a mold for plastic, determine the amount of liquid ounces required to fill the container to a level just below the top. Now convert the liquid ounces into cubic centimeters because you will be working with very small amounts. Once you have converted the ounces into cubic centimeters, divide this amount by 3, because the plastic block is constructed in three equal layers.

Apply a mold release compound to the entire inner portion of the container to prevent the resin from sticking and to provide easy release.

Now that you have determined the cubic centimeters of resin required for the first layer and you have prepared your mold, pour the resin into a disposable container and add catalyst to the resin at a ratio of 4 drops of catalyst to 5 cubic centimeters of resin. Stir this mixture smoothly and thoroughly for about 1 minute (being very cautious not to create bubbles in the mixture), pour into the mold, and cover in a tent-like fashion to prevent dust from settling on the resin and allowing volatile fumes to evaporate. Let this mixture set for at least 2 hours, and it should set long enough that the mixture is just to the point of being a tacky gel.

The first layer is now prepared to support the specimen. Remove with tweezers the specimen from the resin in which it has been soaking and let the excess resin drain off. Place the specimen in the center of the mold upside down and allow it to set for a couple of hours under a tent cover. This will prevent the specimen from floating when the second layer of resin is poured. Mix catalyst with enough resin to make up the second layer and slowly pour the mixture into the mold from one end. This will allow the fluid to push all air away from the specimen. Let this layer dry under a tent to the point of being tacky, and then mix and pour the third layer. Allow to dry under a tent cover for approximately 12 hours at room temperature and then place the mold in a "light bulb oven." The mold should cure for about 4 hours in 140° Fahrenheit (60.48° Celsius). After the mold has cured for the recommended time, turn off the light bulb and let the mold stay in the oven until it returns to room temperature. The plastic-preserved specimen is now ready to be removed from the mold; however, it is not in a finished condition.

The plastic block must be ground and polished for it to be in a display condition. To grind the block, lay a sheet of coarse emery paper (180 grit) on a moistened smooth surface with the grit up. Pour a small puddle of water in the center of the paper and grind the six sides of the block, using back and forth motions in the water. After you have ground the six sides of the block using the coarse grit paper, follow the same procedure using an intermediate grit, and then use a fine grit paper. After you have completed the grinding process, place a very small amount of liquid *abrasive* on a felt polishing board and rub all six sides of the block in the abrasive, using back and forth motions. At this point the block should be becoming much more smooth and transparent.

Next, place a very small amount of liquid *polish* on another felt board and follow the same procedures that were used with the liquid abrasive. Your plastic preserved specimen is now complete and ready for display.

Exercises (216):

1. The purpose for presoaking specimens in uncatalyzed resin is to ______________________.

2. The ratio of catalyst to resin is __________ drops of catalyst to __________ cubic centimeters of resin.

3. When grinding the plastic block for finishing, what type of motion is used?

4. List the procedures for determining the cubic centimeters of resin required for each layer when measured in ounces.

217. Specify techniques and materials required for preserving specimens on slides.

Preserving Specimens on Slides. The preservation of specimens on slides is an ideal method to be used when very small specimens are to be viewed. This method is very difficult, and a lot of experience is required to obtain professional results. Although you may not be experienced at preparing slides, you can still prepare appealing slides by following the procedures set forth.

Prior to mounting a specimen on a slide, it must first be prepared. The specimen must be soft to prevent breakage, and it must be cleared of internal body tissues to make it transparent. To do this, the specimen is placed and left in a cold solution of 10 percent caustic potash in water for approximately 12 hours. Remove the potash solution by using an eyedropper (being careful not to lose the specimen) and replace the potash soltution with plain tap water still using the eyedropper. Repeat the rinse several times to insure that all of the potash solution has been cleared from the specimen. Now, examine the specimen under a microscope to insure that all internal tissues have been completely dissolved. If the tissues have not dissolved, return the specimen to the potash solution and allow it to soak again (it may be necessary to boil the solution for about 5 minutes if the specimen is large), following the procedures previously mentioned.

After the specimen has been rendered free of all internal tissues and thoroughly rinsed, it is ready to be dehydrated and cleared. Select two small dishes that have wide bottoms and pour a small amount of glacial acetic acid (dehydrating fluid) in one and a small amount of clove oil (cleaning fluid) in the other. *Keep the fluids covered tightly at all times except when it is necessary to open them for transferring the specimen.* If the specimen appears to be too dark to be transparent, it should be bleached by immersing it in a weak bleach solution along with a couple of drops of glacial acetic acid for about 5 minutes prior to beginning the normal dehydration and clearing process.

Now place the specimen in the glacial acetic acid. If the specimen is too transparent it can be darkened by adding a few drops of solution containing acid fuchsin and 20 percent alcohol to the glacial (acetic acid) and leaving it there for 5 minutes. Using forceps, remove the specimen from the acetic acid and place it on blotting paper; then pick it up and place it in the clove oil. Let the specimen remain in the clove oil for 5 minutes and remove it.

Reexamine the specimen under a microscope to check for cloudy blotches. If blotches appear, this indicates that all the water has not been removed and you must return the specimen to the acetic acid and again to the clove oil. However, if there are no blotches, the specimen is now ready for mounting on the slide.

Place the specimen on the slide and arrange it in the manner you want to display it. Blot the excess clove oil off the specimen and slide with a piece of blotting paper and then drop a very small amount of Canada balsam on the specimen. The Canada balsam should be thick enough to barely allow it to run. To thin the balsam, add a drop or two of xylol and let it dissolve naturally. After the balsam has been applied to the specimen, cover the balsam and specimen immediately with a cover slip that is appropriate in size for the specimen. The cover slip should be applied by placing one end of it down on the slide and gently lower the other end. Do not drop the cover slip down on to the specimen because it will trap air bubbles.

Once the specimen is mounted on the slide, handle it with care and keep it in a horizontal position for several weeks because it takes this long for the balsam to dry. Before putting it away to dry, prepare two labels with the required information previously discussed and place one label on each end of the slide as illustrated in figure 2-22.

Exercises (217):

1. To soften a specimen being prepared for mounting on a slide, the specimen is placed in a cold solution of ______________________ for a period of ______________.

2. A weak bleach solution is used to ______________ specimens that are to be mounted on slides.

3. What fluid is used for cleaning internal tissues of specimens being mounted on slides?

4. To darken a specimen that is to be mounted on a slide, a few drops of solution containing ______________________ and 20 percent alcohol is added to the glacial.

5. Upon reexamining a specimen under a microscope, the appearance of blotches indicates that all the ______________ has not been removed.

6. Glacial acetic acid is used to ______________ specimens for slide mounting.

7. To dissolve the internal tissues of specimens to be mounted on slides, a solution containing 10 percent ______________________ is used.

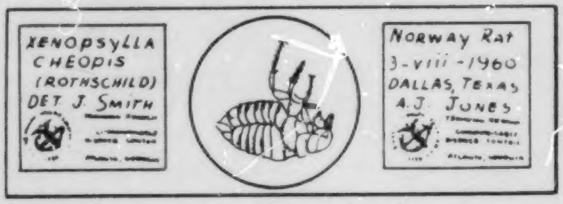

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Figure 2-22. Labeling technique for slide mounted specimen.

2-3. Pest Management Principles

You are the major contributor to an effective pest control program. However, it is essential for you to realize that an effective program may be broader in scope than the boundaries of the airbase that establish your perimeter of operation. In many instances, the planning of your pest control program is based upon more far-reaching plans established by municipal, county, State, or Federal agencies. You must place your program in its correct relationship to the more generalized program and strive to have it make its desired contribution.

218. Match responsibilities with appropriate agencies and specify the agency or agencies that would normally become involved in given situations.

Pest Management Responsibilities. All echelons of command must insure effective control of pests which are injurious to health; affect morale; or damage physical structures, vegetation, and other property. Responsibilities in connection with pest management at Department of the Air Force installations are contained in AFM 91-16, *Military Entomology Operational Handbook;* AFM 91-19, *Herbicide Manual for Noncropland Weeds;* AFM 126-1, *Conservation and Management of Natural Resources;* AFR 91-21, *Pest Management Program;* AFR 91-22, *Aerial Dispersal of Pesticides;* AFR 20-36, *Armed Forces Pest Control Board;* AFR 8-14, *Air Force Occupational Safety and Health (AFOSH) Standards;* AFR 127-12, *Air Force Occupational Safety and Health Program* (PA); AFR 161-71; *Disinsection of Aircraft;* and AFR 161-4, *Medical and Agricultural Foreign and Domestic Quarantine Regulations for Vessels, Aircraft, and other Transport of the Armed Forces.* Any deviations from these guidelines must be fully justified.

Major command. The commander of each major command must insure the establishment and execution of effective pest management programs at all installations under his jurisdiction, and provide technical supervision and training for personnel engaged in these activities.

Installation commander. Each installation commander established measures to protect health, morale, and property, and to prevent transportation of pests from one location to another by aircraft. Installation commanders ascertain that all personnel engaged in pest management are adequately trained and thoroughly familiar with all phases of this activity.

Civil engineer. The civil engineer initiates and supervises the planning and execution of all insect, rodent, and other pest control activities. Planning and execution include residual treatment of aircraft; providing personnel with necessary protective clothing, equipment, and personal hygiene facilities when handling toxic materials; and assisting appropriate accountable officers with inspections for the protection of subsistence supplies, clothing, and materials stored in depots and warehouses.

Medical service. The medical service determines the need for and recommends appropriate pest management programs to preserve health and welfare; advises on control measures and chemicals employed; advises on and monitors health protection measures afforded personnel in handling toxic materials; and determines the adequacy of pest management programs.

Exercises (218):

1. Match responsibilities with the responsible agency by placing the letter beside the appropriate number.

	Responsibility	*Agency*
_____	1. Establishes measures to protect health, morale, and property, prevent the transfer of pests from one location to another by aircraft.	a. Major command. b. Installation commander. c. Civil engineer. d. Medical service.
_____	2. Insures the establishment and execution of effective pest management programs at installations within jurisdiction.	
_____	3. Determines the requirements for and recommends appropriate pest management programs to preserve health and welfare of personnel.	
_____	4. Initiates and supervises the planning and execution of all pest management programs.	

2. The agency that should be contacted to support you in justifying requirements for personal protective devices and facilities is the _____________________.

3. The agency that should be contacted with regard to determining the appropriate pesticide and control measure to be used when in doubt at base level is the _____________________________________.

219. State the methods used in determining pest management requirements and identify the informational source that applied to statements provided.

Determining Pest Management Requirements. One method for determining the need for pest management is an after-the-fact situation. This is nothing more than implementing management programs after the pests have become established. Although this method is often used, it is not the best approach. Pest management requirements can most often be determined long before the pests can become established. Being capable of predicting a problem and establishing preventive measures to ward off the problem is the sign of a professional pest manager. This objective describes the methods used in predicting pest problems.

Local data and records. There are many sources available, on and off base, that will provide you with enough information to make reliable predictions as to the type of pests that may cause problems, areas that may require special attention, and the time of year that problems most likely will exist.

The *US Air Force Meteorological Office* and the *National Weather Service* are the sources available for gathering information concerning rainfall, temperatures, wind speed, and wind directions.

These agencies can provide you with data that depicts the average rainfall and temperature for each month of the year based upon many years of recordkeeping. This data alone will give you a good idea as to the types of pests most likely to be prevelent within the area and when the problems will most likely occur. These agencies can also provide you with information pertaining to the average wind direction and speed during certain times of the year. This information can be used for recognizing the possibility of pests being blown in from areas surrounding the base, where pests are known to be or suspected of being prevalent.

Now, you may be asking yourself, how am I to know what pests are prevalent off base? This question may be answered by the following.

The *County Extension Office* maintains and distributes pamphlets and bulletins concerning agricultural pests in the area.

The *County Health Office* is normally responsible for managing health-related pests and can provide you with information pertaining to medically important pests prevalent in the area. This office can also provide information as to the terrain conditions in areas adjacent to the base.

There are many sources of information that can be used in determining pest management requirements and local cylindrical characteristics of pests within your own organization. The *Annual Pest Control Plan* is a document prepared by personnel just like yourself. Copies of this plan are maintained within the programs section and the entomology section and can be used for gathering information pertaining to previous problem pests, problem areas, and management techniques. This plan can also offer support in making your prediction as to future pest problems.

The *Pest Summary Report* is a valuable source for gathering information pertaining to all pests that have been prevalent on base. This report also states the type of areas where certain pests have been located, pesticides that have been previously employed in management, pesticide formulations previously used, type of treatment applied, and the hours expended in specific areas.

Still another source for obtaining information is the *Pest Control Historical Report*. This is a card file index for each facility on base that provides a complete record of each visit by pest management personnel to that facility. By reviewing this card file you can see which facilities offer the most problems based upon the frequency of visits. You can also learn what pests are prevalent to each facility, pesticide, and pesticide formulation most generally used in control efforts, and the hours expended on each facility.

In addition to using local data and records as a method to be used for providing you with information to determine pest management requirements, the original/basic survey must be conducted.

Original/basic survey. In order to complete this objective refer to objective 210 and review the information pertaining to the original/basic survey.

Exercises (219):

1. What are the two methods that are used for determining pest management requirements?

2. The informational source that provides you with terrain conditions in areas adjacent to the base is the ________________.

3. List two agencies that can provide you with information pertaining to pests within the area.

4. List information that you can obtain from the Air Force Meteorological Officer concerning conditions that would aid in determining pest management requirements.

5. If you wanted to know the frequency with which a particular facility on base has been treated for a specific pest, you would review the ________________ ________________.

6. The document that will provide you with information pertaining to the type of treatment previously used for managing certain pests is the ________________.

7. The informational source that provides you with information pertaining to actual conditions that are conducive to pest infestations is the ________ ________________.

220. Match the process of selecting pest management procedures with the factors to be considered.

Basis for Selecting Pest Management Procedures. Selecting pest management procedures is not an easy task and it certainly cannot be done without considering many aspects. These aspects must be thoroughly analyzed and is the intent of this objective.

Pest to be controlled. The first step that must be taken in every situation is to identify the pest. In most cases pests must be identified to species because many pests within the same genera have different habitats and habits, thus requiring different control techniques.

After the pest has been identified, you must consider another point: is the pest more detrimental than beneficial? This question may raise another question: how can a pest be beneficial? To help you in understanding this, the word *pest* should be defined. A pest can be *any undesirable plant or animal;* furthermore, a plant or animal can be very beneficial. But, in a particular place and at a particular time, the same beneficial plant or animal can be a pest.

If the pest is more beneficial than detrimental, then control techniques other than killing should be implemented if possible.

Location of pests. After you have identified the pests, the next aspect that you must consider is the location of the pest. The location of the problem is very important because this determines the urgency, materials, equipment, and personnel required for managing the pests.

An example of this would be honeybees in the wheel well of an alert aircraft; therefore, the bees must be removed promptly by using pesticides. However, if the same honeybees had located in an abandoned automobile they could have been removed by gathering the queen bee and transporting her to another area, causing the others to follow.

If the pests are located on vegetation, control measures must be implemented that would not be detrimental to the vegetation. Formulations of oil solutions must certainly be avoided in this instance.

Managing pests that are located in aquatic areas is still another problem which must be handled with great care, especially if this aquatic area happens to be a stream, pond, or lake. *During the planning stage for developing pest management programs related to all aquatic pests, insure that you know Federal and State laws governing environmental protection.* There are certain aquatic pest management procedures that cannot be used; for instance, some States will not allow chemical treatment of aquatic areas in controlling aquatic breeding pests and aquatic vegetation. With this in mind, you must know other control measures that can be used to deal with the problem.

(NOTE: Types of controls and control measures will be discussed separately within this section.)

Take a look at another situation where pest location determines the management procedure even when dealing with the same pest specie. To manage German cockroaches in a base dining facility, you can only apply pesticides to cracks and crevices, which is nothing more than spot treatment. However, if these same cockroaches had been located in a billeting facility, a pesticide residual could have been applied to baseboards, walls, and ceilings.

Taking this example a little further, assume that these same cockroaches are located in an electrical panel box in a base billeting facility. In this situation, base policy requires two people for the job when entering billeting facilities. In addition, it would require the use of a pesticidal dust formulation and a hand-bulb duster to reduce fire and electrical hazards.

Here is another example that will illustrate the importance of the pests' locations that involves a different type of pest. A base facility is heavily infested with dry-wood termites and if not treated very soon, the damage will spread to such a degree that it will make the facility unsafe. Being aware of this fact, you know that it must be treated at once. Having knowledge of dry-wood termites, you also know that they must be managed by performing fumigation operations which require a fumigant, specialized equipment and materials, and a minimum of two people. In this example, you have seen the job was urgent to preclude further damage and spread of infestation, and you also noticed that it dictated the materials, equipment, and personnel required to perform the operations.

There are many other situations that could be identified to exemplifying the importance of pests' locations when selecting pest management procedures; but there is no need, because it can be understood at this point.

Environmental conditions. Environmental conditions play a very important role in selecting pest management procedures. In some situations, winds predict the time, place, and type of control to be used. Generally, outdoor spraying operations will not be performed when wind speeds exceeding 8 mph create drift hazards. Ourdoor fogging and ultra-low-volume dispersal operations should never be accomplished with wind speeds exceeding 8 mph because chemicals would be blown away which would result in a waste of materials, time, and effort and at the same time jeopardize other elements within the environment.

Moderate winds can be quite beneficial in treating areas such as ponds and tall trees that otherwise cannot be treated with normal pesticide dispersal equipment.

Rain can wash away residual sprays that have been applied to trees, shrubs, and grasses for controlling vegetation pests and make reaccomplishment necessary. In view of this, residual spraying operations should not be performed prior to suspected rainfall. Rains will also necessitate the reaccomplishment of mosquito larvicide operations in some cases. In other cases the rain may act as a natual control by causing an overflow of water holding areas that contain mosquito larvae, thus eliminating the need for implementing controls.

Rains can also bring problems with pests that are not normally encountered during dry weather. During continuous rainy conditions there seems to be an overabundance of mosquitoes, snails, and slugs. Flies, cockroaches, earwigs, crickets, rats and mice, along with many other pests cause unusual concern to building occupants during rainy periods, and at the same time, fungi causes great concern because it thrives on moisture.

Considering environmental conditions as a basis for selecting pest management procedures involves much more than just the wind and rain. All aspects of the environment must be considered. The terrain and presence of all beneficial plants and animals must be considered at all times to prevent contamination of water sources and the killing of nontarget organisms.

Permanent or temporary controls. Consideration must be given to the long-range plans for the installation to which you are assigned if you decide if permanent or temporary controls are to be emphasized. If there are long-range plans for the base or installation to be in existence, permanent controls should be emphasized.

Initially, permanent controls may be more expensive than temporary controls but most often will be less expensive in terms of repeated use of materials, equipment, and man-hours expended through temporary controls. Permanent control measures can sometimes be coordinated with other base activities. For instance, if an area is being excavated, arrangements can be made to use the earth to fill mosquito breeding areas as long as it doesn't violate environmental protection policies within the area.

Temporary controls must be considered on the basis of merit. These controls offer no long-term benefits; however, as previously stated, they are normally less expensive initially. Temporary controls are required in situations such as reacting to emergency pest problems and operating on an austere budget. When temporary controls are implemented it must be understood that these are only controls to offer immediate relief, and you should be thinking of permanent controls that would prevent reoccurrences of the same problem.

When selecting permanent or temporary pest management procedures, you must consider the urgency of the problem, environmental protection laws, and available resources such as personnel, time, materials, and equipment.

Although permanent control programs are generally most difficult to sell to the higher echelons of management, they are the best and least expensive in the long range and should be stressed. Selling this program to the higher levels of management requires strong justification and is entirely dependent upon your ability in presenting all facts.

Available resources. Your selection of pest management procedures is partially based upon the resources that are available to you. Some pest management programs that you would like to implement may be impossible due to the nonavailability of certain types of equipment and materials. Other barriers that might be in your way is a shortage of personnel and funds.

When confronted with these problems, it is your responsibility to obtain the resources required to select and develop an alternative pest management program that will be safe and effective.

Safety and effectiveness. The safety and effectiveness of pest management procedures are the two most important aspects to be considered, and all phases of pest management planning must be based upon them.

Safety is the first and most important aspect to be considered. If you think a program cannot be accomplished safely, then it should be abolished and an alternative method implemented, even though it may be less effective.

There are many programs that can be used effectively in managing pests, but when selecting a program that is safe and still effective, it reduces the number of choices considerably.

Exercises (220):

Match the statements concerning the selection of pest management procedures with the factors to be considered by placing the appropriate number or numbers beside the applicable letter. NOTE: More than one factor may be considered for each statement.

_____ 1. Pests to be controlled.
_____ 2. Location of pests.
_____ 3. Environmental conditions.
_____ 4. Permanent or temporary controls.
_____ 5. Available resources.
_____ 6. Safety and effectiveness.

a. Considering the number of personnel to do the job.
b. Determining the detrimental and beneficial aspects.
c. Considering the topography of immediate area.
d. Determining the urgency for implementing controls.
e. Considering long-range plans for the base or installation.
f. Analyzing merits of pest management programs.

221. Match situations that require coordination for pest management with the activity/activities with which they should coordinate.

Pest Management Coordination. To effectively maintain a pest management program, there must be close coordination between the entomology section and other sections within the organization. In addition, close coordination is required with many other activities on and off base. The quality and quantity of support rendered by various activities will be greatly dependent upon your knowledge of the responsibilities and capabilities of each activity and also your ability to process requests tactfully, expediently, and properly.

Base and command activities and responsibilities. Understanding the responsibilities and capabilities of the available activities that commonly require coordination is the object of this discussion.

There are many activities within your own organization that can render immense support, upon approval, in pest management from the very beginning (planning stage) to the end (pests being managed.)

The Programs Section becomes involved in every pest management program. The degree of involvement is dependent upon the scope of each pest management program. If pest management can be accomplished with a service call the programs section may only be required to record the expenditures, location, and type of treatment performed; however, if it requires work order accomplishment, then the programs section becomes much more involved. Through your assistance the Programs Section must develop a program by identifying the location and urgency of the job, type of work to be performed, materials and equipment required, other sections to be involved, and sequence of events. Based upon this information, the Programs Section must estimate the total cost of the pest management program, obtain work order approval materials and equipment required, schedule sequence of events, and monitor all phases of the program.

The sections within your own career ladder than can offer support are the Refuse Collection and Disposal and Environmental Support Sections. The Refuse Collection and Disposal Section can make your job much easier by exercising proper techniques in the collection and disposal of base refuse. Through frequent and proper collection and disposal of refuse, breeding matter, food sources, and harborages for pests are eliminated, thereby reducing conditions that are conducive to pest infestations.

The Environmental Support Section can often assist you in maintaining the pumps on pesticide dispersal equipment. In doing this, maintenance expenses are reduced and the ability to perform pest management operations is increased. While on the subject of equipment maintenance, take a look at the other sections within your own organization that can offer assistance.

Power Production can be very instrumental in performing maintenance on many four-cylinder engines used on pesticide dispersal equipment; whereas Pavements and Grounds can help in maintaining two-cylinder engines on the equipment. Protective Coating can be very helpful in reconditioning your equipment by removing corrosion and deteriorated paint and by reapplying a coating system. Metal Working can assist in straightening and repairing most metals associated with powered pesticide dispersal equipment and fabricating certain metal items used for equipment modifications. In addition, this section can fabricate bait stations and shields to be used in pestproofing base facilities.

The Carpentry and Masonry Sections within civil engineering plays a very important role in many pest management programs. They are responsible for removing portions of structures when necessary to enable you in getting to the source of pest problems; and following this, they must replace or repair portions removed or damaged. These sections can also assist in pestproofing base facilities by repairing or replacing doors, windows, and screens and by filling in or covering up cracks and crevices in walls and ceilings and around pipes that enter the building.

The Plumbing and Heat Systems Sections are important in identifying the location of water, steam, and fire-extinguishing lines in all areas of the base. This often becomes necessary when you are involved in treating for subterranean termites.

The Interior Electric Section is an invaluable source for obtaining information pertaining to the location of electrical wiring and panel boxes. Many pest management situations require that electrical power be shut off to facilities prior to performing management operations. When fogging or aerosoling indoors, electrical power must be shut off to reduce explosion and fire hazards.

Exterior Electric Sections assist in running power lines to areas for operating light traps in conducting surveys and providing high-reach equipment and operators when performing pest management operations such as removing bird nests from hangars, birdproofing buildings, and picking bagworms or prunning trees to remove webworm nests.

The Equipment Section, along with Pavements and Grounds Section, becomes involved when pest management programs include excavating or filling to eliminate mosquito breeding areas and to provide an appropriate grade allowing water to drain away from buildings to resolve conditions that would be conducive to decay, fungi, and termites.

As you have seen, almost all, if not all, sections within your own organization have a hand in pest management every now and then to make you job easier and more professional; but there are even more activities on base that assist in pest management.

Environmental Health Personnel are responsible for conducting surveys for health-related pests on base and for making recommendations as to the management programs to be implemented against medically related pests. They are also responsible for monitoring the types of pesticides used on base and the management techniques employed. This section monitors industrial-related health hazards and performs physicals on individuals who work in areas that have been identified as hazardous or in food serving facilities.

As a pest manager, you will be required to have occupational physicals performed periodically by these individuals to test your hearing and to determine the levels of toxic chemicals within your body.

The Base Veterinary Services is responsible for insuring that base facilities are kept clean at all times, especially base dining and food service facilities. Through the combined efforts of you and the base veterinary services, many pests can be managed effectively and safely by recognizing unsanitary conditions and taking immediate actions to correct them. The base veterinary services also provides great support in the detection of stored produce pests and controlling diseases that are transmitted by dogs, cats, skunks, and other animals of this type that happen to be on base.

The Ground Safety Office provides support in obtaining safety items that can be justified to improve safety standards during pest management operations. Personnel within this office perform periodic inspections to observe personnel that are on the job performing to detect unsafe practices and unsafe conditions. Do not belittle this approach taken by the ground safety representatives, because it is a very important program designed to protect you and your coworkers. If your shop is not adequate for storing and mixing pesticides or if it is not properly lighted, the Ground Safety Office personnel are the people you should contact if you have been unable to get support within your own organization.

The Traffic Management Branch within the transportation organization becomes involved with clearing railcars that have been fumigated with Phostoxin. The freight section must notify you upon the arrival of a fumigated railcar, and they must conduct the actual removal of the securing seal.

Other branches such as Traffic Management and Vehicle Maintenance can provide you support in obtaining additional means of transportation when required. They will maintain the vehicle assigned to your section, with the exception of performing operator maintenance, which is your responsibility.

Of course, there are many more activities on base that you will have a need to coordinate with from time to time such as the Base Information Office and field maintenance organization; but, the ones that have been discussed are the activities you will be coordinating with most often.

Coordinating with *major commands* is generally restricted to problems that cannot be accomplished at base level concerning pest management and to certification/recertification of pest managers. If you have questions concerning any pest management situation that you feel has not been answered adequately from sources on base, then you should request assistance from the command entomologist or representative of that function using the proper chain of command.

Coordination with the major command is required anytime it is believed that pest management must be accomplished by dispersing pesticides with aircraft. There are many pest management programs and pesticides that must be approved at major command level prior to their use. Be sure that the program that you have planned is safe and is an authorized program before you implement it, unless you have received prior approval.

The US Public Health Service has funds that are available for controlling malaria, typhus, and other diseases that appear on private property adjacent to Air Force bases. If these disease-carrying pests constitute a menace to the health of Air Force personnel, the base commander may request, through proper Air Force command, that the Public Health Service make a survey of the surrounding area. If the survey shows the existence of a dangerous condition, the agency will perform the work at its own expense.

Many of the management procedures now used to combat pests have been developed by the Bureau of Entomology and Plant Quarantine of the US Department of Agriculture. Personnel from this department may assist the civil engineer in the control of termites, Japanese beetles, grasshoppers, etc. However, the request for assistance must be sent directly to the Department of Agriculture.

The Fish and Wildlife Service of the US Department of Interior may give, upon request, technical aid in controlling rats, mice, ground squirrels, other rodent pests, and coyotes.

State, county, and city control agencies are very important to the Air Force, because they carry on active mosquito control operations and cooperate in keeping down the occurrence of rats, flies, and other pests off base. On the other hand, it is the responsibility of the base civil engineer to eliminate base conditions that might adversely affect the surrounding community. Close cooperation, both on and off base, is essential if effective results are to be obtained in the war against pests.

Exercise (221):

1. Match the problem situation with the activity or activities it should be coordinated with in obtaining assistance in pest management by placing the appropriate letter or letters beside the applicable number.

Problem Situation

____ 1. A pump on the powered dispersal equipment needs repairing.

____ 2. The location of panel boxes and wiring needs to be identified inside a facility prior to performing pest management operations.

____ 3. An additional vehicle is required in order to accomplish a specific type of pest management operation.

____ 4. A pest problem exists on base and the only way it can be brought under control is by aerial dispersal of pesticides.

____ 5. Assistance is required from sources off base to control Japanese beetles.

____ 6. Assistance is required in overhauling a four-cylinder engine on the Buffalo turbine.

____ 7. Surveys are needed to determine the presence of medically related pests.

____ 8. Additional information is needed concerning the safety aspect of a particular pest management program.

____ 9. A basewide pest management program is to be implemented.

Activity

a. Base Information Office
b. Environmental Health.
c. Environmental Support.
d. Ground Safety
e. Interior Electric
f. Major Command
g. Power Production
h. Traffic Management
i. US Dept of Agriculture.
j. US Dept of the Interior.
k. Base Veterinary Services
l. Exterior Electric
m. Protective Coating
n. US Public Health Services.

and all personnel on base must be advised as to when the program will be implemented and the actions required from them.

____ 10. Technical assistance is required for controlling coyotes that have become established on base.

____ 11. Support is needed in demanding that unsanitary conditions indoors be corrected.

222. Given pest management situations, list the types of controls that are involved in each of the situations.

Types of Controls. Before you can coordinate pest management programs, it is essential that you know the types of controls and the facts pertaining to these types of controls. All pests are managed by natural and applied controls.

Natural controls. This is a method in which pests are controlled by natural environmental conditions. Many pests cannot survive in extreme or prolonged temperatures. This is indicated by the presence of numerous pests in warm temperature regions and very few pests in regions that have four distinct seasons, where pest problems are more seasonal.

Rain controls many pests by beating them from plants and overflowing artificial containers, potholes, ditches, and small ponds exposing eggs and larvae, causing them to dry up.

Most pests require moisture; therefore, very dry weather will preclude many pests from becoming established within an area and will also cause many to die.

Almost all living elements within the environment have natural predators and these predators contribute immensely to managing many pests. This is nature's way of helping to maintain a balance between the living elements.

Applied Controls. This type of control is implemented when nature cannot maintain the balance of living elements within the environment or when it becomes necessary to control pests that have no natural enemies within the area and to control pests rapidly.

Applied controls include all controls that have been implemented by people. Anytime someone becomes involved in managing pests, whether it be direct killing or introducing predators to the area for them to do the killing, it is still considered to be an applied control.

There are two basic applied control principles that can be implemented in managing pests. All applied controls are either *preventive* or *corrective*, and many will be a combination of the two.

a. Preventive controls. As previously stated, preventive controls are preferred because they are designed to forestall pest infestations and they are the most economical. Preventive controls include maintaining high standards in sanitation, constructing facilities in a fashion that will keep pests on the outside, landscaping areas to provide adequate drainage of water, and maintaining an effective quarantine program. These are only a few of the many preventive controls that can be implemented, and many of these will be recognized as forms of corrective controls. The only difference will be in the sequence of occurrence.

b. Corrective controls. These controls are rated in last place because they are designed to cope with pest problems that already exist; however, they do play a very important role in pest management. Corrective controls are required in many situations to quickly reduce or arrest pest problems of medical and economical importance.

Exercises (222):

1. While conducting the original/basic survey, you noticed that there were several shrubs heavily infested with aphids. You also observed that the shrubs had not received any noticeable damage and that there were several mantids on the shrubs. Knowing that the mantids are predacious to aphids, the type/types of control/controls most appropriate for this situation would be ____________.
2. While conducting a termite and wood decay inspection on base facilities, you observed several water leaks within the plumbing system beneath the building. Knowing that this presents a condition that would be very conducive to subterrannean termites and fungi, you turn in a job order to have the pipes repaired or replaced. The type/types of control/controls involved in this situation would be ____________________________
3. You received a service call concerning flies in a dormitory on base and you responded by conducting a survey. During the survey you found that houseflies were the problem, and the source of the problem was decaying grass clippings which had been piled but not removed. You also found that the flies were entering the building through window screens that were deteriorated. Therefore, you informed the building custodian of what you had found and stated that the grass clippings must be removed and a job order must be submitted to civil engineering to replace or repair the window screens. The type/types of control/controls taken in this situation would be ____________________ ____________________________.
4. During a survey to determine the presence of mosquito larvae, you collected several larvae in a pond that is stocked with fish as a part of the base recreation program. Knowing that you cannot use pesticides in the pond for fear of killing the fish, you initiate a program of introducing gambusia minnows into the pond too, since they are predacious to mosquito larvae. This would be ____________________________ control/controls.
5. You have been informed that a new facility is to be constructed on base, and you request permission to review the contract. Reviewing the contract you

find that there are no provisions for soil poisoning at the sight of construction; therefore, you request that this provision be included and accomplished prior to construction. This would be a form of ______________________ control/controls.

223. Compare applied pest control measures and match control measures with the appropriate type of applied controls.

Applied Controls. There are six specific types of applied controls that can be used in managing pests, and in many situations you will be using more than one at a time. When a combination of specific controls is implemented simultaneously in a particular pest management program, this is referred to as an integrated control.

Remember, applied controls are control measures that are implemented by individuals, and they can be preventive and corrective, depending upon the control measure used and when it is used.

Five of the six specific applied controls are *nonchemical controls*, which are the types that should be considered first because they present fewer hazards to the environment and in most situations these controls are more permanent. Therefore, the five nonchemical applied controls will be discussed first.

Legal controls. These are control measures implemented to prevent the spread of destructive or harmful pests to areas that are presently relatively free from these pests. Quarantine operations are designed for this purpose. If you have traveled to other countries or even certain states, you may have been involved with a form of legal control when passing through agricultural quarantine inspection stations.

Biological controls. These controls involve the introduction, production, and release of parasites, predators, and diseases, which in turn, attack and reduce or control harmful arthropods. Other aspects of biological control is the protection of insectivorous arthropods; propogation and spread of disease-producing protozoa, bacteria, fungi, and viruses; and the production and release of diseased arthropods.

You will have very little, if any, control over legal and biological controls because these are established and implemented by other Federal agencies; however, you must be knowledgeable of these controls and recommend or utilize them when warranted.

As an entomology specialist, you must be knowledgeable of the remaining three nonchemical controls because these are extremely important to you and other base personnel.

Construction and maintenance controls. This applied control measure involves the proper erection and reparation of facilities and grounds. Proper construction and maintenance is intended to "build out" pests.

Grounds should be prepared and maintained to allow proper drainage away from facilities and to ~~eliminate~~ [illegible] low-lying areas that frequently hold water.

Facilities should be constructed with termite shields where applicable, tight-fitting doors and screens, sufficient roof overhang, and proper ventilation in attics and beneath floors.

Mechanical controls. These controls involve the use of devices designed for the mechanical destruction or exclusion of harmful and destructive arthropod pests. These devices include items such as traps and barriers and may involve the physical removal of pests.

Sanitation controls. To pest managers, sanitation control measures are considered the most important because when proper sanitation techniques are applied it removes the elements that are required for pest survival. Sanitation control is the prime preventive and corrective measure to be implemented. Proper sanitation removes the food, water, and harborage that would attract or support pest populations. Sanitation control measures include, but are not limited to, keeping facilities free of dirt, crumbs, and grease; keeping lawns and adjacent areas mowed and free of rubbish, such as cans, bottles, vines, and brush; storing refuse in tightly sealed containers; collecting refuse frequently and carefully; and disposing of refuse in a proper manner.

As can be seen, there are many control measures available for managing pests, and none involves the use of chemicals. Sanitation, construction and maintenance, and mechanical control measures should be given prime consideration and implemented whenever possible to reduce or eliminate environmental hazards.

Chemical controls. Now that each of the five nonchemical controls has been discussed, it is time to discuss chemical controls. These have been placed last because they should be considered as a last resort. At times, chemical control is essential for rapid elimination or reduction of pest populations, especially during natural disasters and epidemics. Under these circumstances, the use of nonchemical principles would be inadequate. However remember that pests cannot be eliminated by using pesticides alone, because this is only a temporary method of control.

Failure to achieve control of a specific pest or disease with a chemical control measure may be the result of local ecological conditions (mutual relations between organisms and their environment), the species involved, formulation or application of the pesticide, pesticide resistance, or faulty timing of the treatment. You must recognize the need to assess the possible influence of each of the factors in any control situation so that you can analyze the problems involved and then select and apply these counter measures that offer the best solution. The ability to plan and effectively conduct an integrated control program is fundamental to achieveing vector control.

Pests can overrun an area in a very short time if control measures are not employed; therefore, it is your responsibility to know the types of controls, when to employ them, and how to maintain control.

Exercises (223):

1. The two applied control measures that you have very little control over because of being established and implemented by other Federal agencies are ____________ and ______________________.
2. The applied control measure that should be used as a last resort is ______________________.
3. The control measure that is considered to be the most effective in preventing pest populations is ______________________.
4. Match control measures with the appropriate type of applied controls by placing the applicable number beside the appropriate letters.

Control Measures

____ a. Introduction of predators.
____ b. Application of pesticides.
____ c. Mowing or removing vegetation.
____ d. Restrictions placed on the entry or exit of certain products.
____ e. Release of sterilized arthropods.
____ f. Installation of windscreen barriers.
____ g. Pestproofing buildings.
____ h. Establishment of proper slope to allow drainage.
____ i. Detention in isolation for observation.
____ j. Rubbish removal.
____ k. Placement of traps.
____ l. Regulated indoor temperatures.

Applied Controls

1. Legal
2. Biological
3. Construction and maintenance
4. Mechanical
5. Sanitation
6. Chemical

224. Given pest management situations, identify the dispersal method to be used in each situation

Pesticide Dispersal Methods. Although several basic methods exist for the dispersal of pesticides, one method is usually better for a specific control situation than any other. The ability to select the best method requires a thorough understanding of the basic principles involved. The basic principles of chemical control methods most commonly used are described below.

Fumigating. Fumigation is the use of gaseous poisons (fumigants) to kill plants and animal pests. The lethal (deadly) activity of fumigants depends on their being drawn into the body through the respiratory system. Because of their extremely small particle size, fumigants must be used in airtight or nearly airtight spaces. This is necessary to prevent dissipation before an adequate exposure period elapses.

Fumigation includes the use of vacuum chambers at major supply depots, the use of calcium cyanide for fumigating rodent burrows, the use of paradichlorobenzene (PDB) or naphthalene for the protection of clothing, and the limited use of methyl bromide in atmospheric fumigation bags and chambers.

Hydrogen phosphide fumigation has recently been introduced and employed by the Armed Forces using aluminum phosphide fumigant. This is extremely beneficial for in-transit fumigation of stored foods to rid the commodities of stored-food pests and has taken the place of many fumigants in in-place fumigation.

Although structural fumigation is most often accomplished by contract, you should be aware that methyl bromide and sulfuryl flouride are two fumigants that are commonly used.

Aerosoling (including fogging and ultra-low volume dispersal). Aerosols may be defined as assemblages of solid or liquid particles suspended in air. Based on the mode of production, there are two principal types of aerosols, cold and thermal. Cold aerosols are usually produced by combining an insecticidal agent with a very low-boiling point liquid and discharging it by its vapor pressure through a small orifice. Thermal aerosols are produced by atomizing a liquid insecticide solution with either hot gases or superheated steam. This insecticide dispersal method is called fogging.

Insecticidal fogging is a method frequently used to free residential areas of adult mosquitoes and sand flies. Consequently, in an area where an insect population is continuous and dominated by migratory species, fogging alone is satisfactory if it is done on a repetitive basis. Because of their small particle sizes, fogs should be used when air movements are minimum and the ground temperature is cooler than the air immediately above it.

The advantage of ultra-low volume dispersal is the capability of dispensing small volumes of concentrated pesticides, as an aerosol, over large areas rather than the conventional diluted formulations.

When pesticides are dispersed as aerosols, the size of the particles range from 0.1 to 50 microns with 80 percent of the particles being less than 30 microns.

Aerosols are generally used indoors for controlling flying insects with exception to the ULV application method and when aerosols are used for the purpose of flushing pests from their harborages.

The aerosols are used frequently in the disinsection of aircraft to prevent introduction of pests uncommon to various regions of the world.

Misting. Mists are dispersed pesticides with intermediate size particles ranging in size from 50 to 100 microns. They are effective methods for outside space treatment. With care, they can be used to considerable advantage for indoor treatment and, because of the large particle sizes, can be used under a wider range of weather conditions than aerosols. Penetration of dense vegetation is less satisfactory with mists than aerosols; however, mists give more residual effect than aerosols.

Mists can be used quite effectively for treating small ponds, lakes, and marshy areas in larviciding operations because the particles will carry much farther in the wind than spray particles.

Spraying. Spraying is defined as the application of liquid pesticides. However, with the appearance of the newer methods of application (aerosoling and misting), spraying is now confined to the application of liquids atomized into droplets of 100 microns in diameter. Because of the larger sizes, spray particles "fall out" more rapidly than mist particles; as a consequence, sprays are principally used for insecticide application to body surfaces or surfaces which pests will contact or ingest at some later date.

Sprays are used in treating food-handling facilities for applying residuals to cracks and crevices and can also be used in applying residuals to interior and exterior surfaces of other base facilities.

Sprays are used extensively in termite treatment operations such as sub-slab injection, soil poisoning, trenching, and for applying herbicides to terrestrial and aquatic vegetative pests.

In addition to the uses already mentioned, sprays can be used for treating sewage-trickling filter beds and for applying residuals to vegetation for controlling pests of vegetation.

Dusting. Dusting is the dispersal of pesticides in the form of solid particles. Generally, the sizes of dust particles are practically the same as liquid particles. Dusts are very effective against crawling insects, particularly those confined to limited areas. If properly applied, dusts are less hazardous to domestic plants and animals than gaseous and liquid pesticides because they are less readily absorbed. If not disturbed, dusts retain their effectiveness longer than liquid applications. For contact killing, dusts take longer to act than volatile liquid materials; they do not adhere well to surfaces; and they do not form a continuous layer over surfaces as liquid applications do.

Dusts should be applied to areas that present electrical hazards such as electrical panel boxes, outlets, and motorized equipment.

Dusts can be applied to indoor and outdoor areas; however, when used indoors, they are generally applied in areas where they cannot be seen due to the unsightly appearance. In outdoor areas, dust are very effective in controlling pests of vegetation and ectoparasites.

Granulating. Granules or pellets impregnated with the desired pesticide has certain advantages over dusts or liquids. They may be used to penetrate heavy vegetative cover. The granular material is designed to liberate the pesticide slowly for longer lasting effectiveness. Granules have been used successfully to release larvicides and herbicides below the water surface for control of mosquito larvae and weeds. This places the pesticide where the greatest benefit will be obtained and avoids loss of the materials by wind action when dust is applied on the water surface.

Granules can also be used for controlling grubs and many other pest larvae that develop below the earth surface because of the slow dissipation rate. In addition, granules are often used for controlling vegetation in many areas.

Baiting. Baits can be prepared as solids or liquids and are generally used in rodent control programs. Baits are prepared by mixing toxicants with many types of food substances, depending upon the substance preferred by the pests you desire to control.

In addition to the use of baits for controlling rodents, baits have been used effectively in the control of snails, cockroaches, ants, and flies.

When baits are used they must be checked and replinished frequently and should be placed in out-of-the way susceptible areas.

Miscellaneous. Frequently, pesticides are applied in an undivided state. The application of pesticides with a paint brush, swab, or roller, and the use of liquid baits and pesticide-soaked bags for the control of mosquito larvae, are common examples of this practice.

Exercises (224):

1. The dispersal method that would probably be most appropriate for treating small ponds and lakes in controlling mosquito larvae is ________________.
2. To treat a large outdoor area for controlling crawling insects without causing harm to vegetation you would use the ____________________ dispersal method.
3. To kill stored-products pests within food commodities the best dispersal method to use would be ______________.
4. ____________________ would be used for flushing many types of pests from their harborages for conducting surveys and to enable a more rapid kill.
5. A dispersal method used in treating rodent burrows to provide quick kill is ________________.
6. The dispersal method that provides the best penetration of heavily vegetated areas is ________.
7. ________________ requires frequent checks and reaccomplishment.

225. Match the type of treatment used in controlling pest arthropods with the appropriate treatment description.

Types of Treatments Used in Controlling Arthropods. The type of treatment to be implemented for managing arthropod pests is a major determining factor in selecting pest management equipment (to be discussed in Volume 3 of this CDC) and the affectiveness of the control program.

There are two basic types of treatment. These are *residual treatments* and *space treatments*, and each of these basic types includes several pesticide dispersal methods which were discussed in the previous objective.

Residual treatment. This is the term applied to the application of pesticides that have the ability to remain effective for several days, weeks, or months to surfaces upon which pests may feed, rest, or crawl. An important characteristic of residual treatments is the fact that pests can be killed during variable periods of time following application. There is no need for the pests to be present at the immediate time of application because they will be killed by contact or ingestion whenever they enter the area and feed or rest on treated surfaces. The length of time for which a residual treatment will remain effective will be dependant upon the type of pesticide, type of surface, exposure to weather or cleaning operation, dosage, and many other factors.

Residuals may be applied as a solution, emulsion, emulsifiable concentrate, technical grade pesticide, suspension, dust, or granule formulations by aerosoling, misting, spraying, dusting, and granulating dispersal methods. Another advantage of residual treatments is the fact that they can be used effectively as preventive and corrective chemical control measures.

The equipment that is to be selected for residual treatment will be dependent upon where the residual is to be applied, the amount of area to be treated, the type of formulation to be applied, and the method in which the formulation is to be applied.

As an example, you would not select an item of manually operated equipment to treat an outdoor area of 2 acres, nor would you select a large item of powered equipment to treat a small room.

Some formulations cannot be used in certain items of equipment, because the equipment is not designed to handle the formulation due to the effect the formulation may have on the pump; or, the equipment may not have an agitator that is required for certain types of formulations.

As an example, due to the way suspensions are formulated, many are corrosive and gritty, which causes damage to certain types of pumps contained on pesticide dispersal equipment, and may clog strainers, distribution lines, and nozzles; therefore, the types of equipment that can be used for applying suspensions as residuals are limited.

Space treatment. This is the term applied to the dispersal of pesticides into the air, indoors and outdoors, to kill pests that are present at the immediate time of treatment.

Space treatments can be accomplished with solution and emulsion formulations and are normally dispersed as fog type aerosols. The solution type formulation is preferred in most situations because the additional solvent provides a quicker knockdown of flying insects.

The advantages of using the space treatment method are immediate knockdown and kill, rapid applications, and the relatively small amount of chemical that is required. This treatment method is most effective indoors where there is very little air movement which permits the fine particles to remain suspended within the air for longer periods of time. A major disadvantage of this treatment method is that it has no residual effect, which means that it has no value as a preventive control measure, and only the pests that are present at the time of treatment are effected.

Miscellaneous treatments. As an Air Force pest manager, you either have been, or will be, confronted with a variety of treatment terms which are nothing more than being a little more specific as to the method for which residual or space treatments are applied. Some of the common examples are the following:

a. Crack and crevice. This is a relatively new term that has evolved in reference to the type of treatment authorized in food handling facilities. This type of treatment is accomplished by applying pesticides only to cracks and crevices within a facility. The purpose for this type of treatment is to reduce the hazards involved with the possible contamination of food and beverage items through the contamination of food preparation and storage areas; cooking, eating, and drinking utensils; serving lines; and dining tables.

Crack and crevice treatment is normally accomplished by using residual solution, emulsion, or dust formulations; however, space treatments can be accomplished by applying aerosols into the cracks and crevices to flush or kill pests that are harboring in these areas.

b. Baseboard treatment. This term is used in reference to the application of residual solutions or emulsions to the baseboards, door facings, and corners of the rooms within a facility. This type of treatment is very common and is probably more often used than any other type for indoor treatment of base facilities, other than those facilities that serve food.

c. Spot treatment. This term can apply to both the crack and crevice treatment and the baseboard treatment or any other residual treatment that is not a complete treatment of an entire area. The spot treatment term is probably more often referred to when speaking of an incomplete treatment of a facility to manage cockroaches, termites, ants, and wasps.

d. Vaporization. This term more often refers to the use of dichlorvos impregnated pellets, tablets, and resin strips for space treatment of warehouses and retrograde cargo. This vaporization type treatment is a form of the fumigation treatment and provides the same results.

e. Larviciding. This term usually refers to the application of chemicals to water for the control of mosquito larvae but may also refer to any such treatment designed to kill larvae of other insects. Equipment that produces either a fine mist or a coarse spray may be used, depending upon whether a heavy, long-lasting residual treatment, or a light application, which will kill only the mosquito larvae, is desired. Larvicides may be applied as liquds or dusts from the ground or air or may be added to the water by other means, such as drip applicators, pellets, or granules.

f. Soil poisoning. The soil in which certain insects live during all or part of the life cycle is sometimes poisoned in attempts to control damage to plant roots or to prevent emergence of the adults. A surface treatment with a water emulsion may be suitable for insects living just under the soil or lawn surface. Deeper penetration is often difficult to obtain in some soils and may not be satisfactory. Termite soil poisoning requires great thoroughness in application, and several types of equipment have been devised for this purpose. Large quantities of dilute formulations applied as coarse sprays are normally used in soil poisoning.

(1) Sub-slab injection. This term is often used to denote the type of treatment employed in poisoning the soil beneath buildings that have concrete flooring that rests directly on the soil surface.

(2) Rodding. This term also applies to soil poisoning and is often used in reference to the insertion of perforated jointed pipe tubings directly beneath flooring and above the soil surface to treat the soil beneath buildings as preventive or corrective control measures for termites.

g. Baiting. The use of poison baits is one of the oldest methods of pest control. The treatment of foilage upon which insects feed, with chemicals that kill by stomach poison action, is another old and common method of treatment. Success with this method depends upon thorough coverage of the leaves with the insecticide. Dilute formulations, containing spreaders and stickers, applied as coarse sprays were used originally, but in recent years there has been a very great increase in application of concentrated formulations as mists with many types and sizes of mist blowers.

h. Systemic poisoning. The most recent development in the control of plant feeders is the systematic poison. That is, a chemical is taken up by the plant and distributed throughout the plant tissues. This is particularly effective against sucking insects that do not feed on the leaf surfaces. The same principle has been applied to the control of ectoparasites on animals by feeding chemicals that are harmless to the host but kill the bloodsucking parasites.

Exercises (225):

Match column A and column B.

	Column A	*Column B*
____	1. No value as preventative control.	a. Residual treatment
____	2. Provides preventative and corrective chemical control.	b. Space treatment
____	3. Effectiveness dependent upon type of surface.	
____	4. Normally dispersed in fog type aerosol.	
____	5. Rapid application and immediate extermination.	
____	6. Equipment used dependent upon area of application.	
____	7. Use of small amounts of chemicals.	
____	8. Insects do not have to be present at time of application to be effective.	
____	9. Baseboard treatment.	
____	10. Spot treatment.	
____	11. Larviciding.	
____	12. Soil poisoning.	
____	13. Baiting.	
____	14. Systemic.	
____	15. Vaporization.	

226. Match the type of treatment used in controlling pest vegetation with the appropriate treatment description.

Types of Treatments Used in Controlling Vegetation. The type of treatment that is to be implemented for managing pest vegetation is also a determining factor in the selection of pest management equipment and the effectiveness of the control program.

Pest vegetation is chemically controlled by applying herbicides directly to foilage, soil, and water, and the application method depends upon the types and locations of the vegetation to be controlled.

Foilage treatment. This type of treatment is used to control existing vegetation by applying the chemical directly to the top growth as contact sprays which produce burning of plant tissues or affects the growth of hormones within the plant.

Basal-bark treatment. This term applies to the application of herbicides to the base of tree trunks and stems that are 6 inches or less in diameter. This type of treatment is well suited for uncut brush and regrowth from cut brush or trees, and particularly for selective control.

Stump treatment. This type of treatment is made to freshly cut stumps by saturating the top and all sides of the stump to the ground line and all exposed roots with an approved herbicide.

Cut-surface treatment. This type of treatment includes the application of herbicides to frills, girdles, cups, or notches that have been made to individual trees.

Treatments to frills and girdles should be accomplished by using a liquid herbicide formulation; however, when treatments are to be made to cups and notches, the herbicide formulation should be crystalline.

Soil treatment. This type of treatment is used to apply herbicides around the base of grasses, trees, and brush when it is desired that the chemical be absorbed through the roots. This type of treatment can be selective or nonselective in form and can be accomplished as a preemergence or postemergence treatment.

a. Selective treatment. This term is used when herbicides are applied to control specific types of vegetation without harming other vegetation that may be mixed in with or within the immediate vicinity of the vegetation to be controlled. This type of treatment is commonly used to control undesirable vegetation that exists in established turf grasses, such as lawns, golf courses, and parade grounds.

b. Nonselective treatment. This term is used to denote the application of herbicides to kill all vegetation within a specific area. This type of treatment is commonly used to control vegetation along side roadways, railroads, and fence rows; beneath utility lines; and around storm drains, culverts, utility poles, and sign posts.

c. Preemergence treatment. As the term implies, this type of treatment is performed to prevent seed germination, thereby preventing the establishment of vegetation.

d. Postemergence treatment. This term is used when herbicides are applied to control vegetation that has already become established.

Ditchbank treatment. This term is often used to distinguish the type of applications being made to irrigation and drainage systems. This, as the term implies, means that herbicides are only being applied to the sloped sides and not in the bottom of the irrigation and drainage systems.

Exercises (226):
Match column A with column B.

	Column A *Description*	*Column B* *Type of Treatment*
_____	1. Preemergence to prevent seed germination.	a. Foliage.
_____	2. Applied to freshly cut stumps.	b. Basal-bark.
_____	3. Applied to drainage systems.	c. Stump
_____	4. Crystalline formulation applied to notches.	d. Cut surface
_____	5. Applied to top growth.	e. Soil
_____	6. Applied to base of trunk.	f. Ditchbank

227. List factors that may determine requirements for conducting research and identify the methods for rendering assistance in each situation.

Pest Management Research. Your participation in research activities will most likely be very limited because most research programs are conducted by other agencies. However, you may be requested to participate in certain phases of pest management research. In any case, before you become involved, insure that all requests have been approved through proper Air Force channels.

Pesticide resistance. This is an increasing problem for pest managers everywhere and your participation in determining actual resistance of pests to pesticides may involve nothing more than insuring that you have prepared and applied the pesticide accurately. However, you may be requested to collect live specimens and ship them to a scientific laboratory so that professionals can conduct further research with the specimens to determine if they are actually a resistant strain.

Effects and effectiveness of pesticides. Intense research is conducted on all pesticides by their manufacturer prior to being placed on the market for purchase, but the only true way to determine the actual effect and effectiveness of the product is for it to be used in many situations and environments. To do this, you may be requested to use an unproven product in controlled situations with furnished guidelines for you to monitor and annotate the effects and effectiveness. Your findings in this research is forwarded to the appropriate agency where other findings are collected and evaluated. If the product meets Federal requirements,it is then approved and can be placed on the market.

The same procedures used in determining the effects and effectiveness of pesticides may be requested of you for determining the effects and effectiveness of new pest management techniques and equipment.

Exercises (227):

1. List in the order discussed the factors that may cause you to become involved in research.

2. Explain your involvement in conducting research for each of the factors you listed previously, and in the order listed.

2-4. Records and Reports

The success and continuity of a sound pest management program is determined by the availability of accurate operational records and reports. Timeliness of control measures, justifiable estimates of funds and personnel needs, and concise requirements for supplies and equipment can only be available by regularly maintaining adequate records. Work accomplished and results achieved must also be uniformly measured and periodically compiled to provide a sound basis of support for the value of preventive control actions.

This section is devoted to identifying records and reports directly related to operational pest management programs that are required to be maintained by pest management personnel and to providing maintenance instructions for each.

228. State the purpose and use of AF Form 483 and specify the information necessary to obtain the form.

AF Form 483, Certificate of Competency. As outlined in AFR 91-21 and AFM 91-16, all personnel engaged in direct field supervision of pest management operations or those who operate independently of direct supervision must be technically competent and thoroughly familiar with all phases of pest management that is being performed.

Purpose. The purpose for this form is to identify individuals who have proven they are competent in handling pesticides in accordance with Federal laws and to insure that they are aware of, and knowledgeable of, current policies relating to all phases of pest management.

Obtaining an AF Form 483. When an individual has demonstrated the technical knowledge and ability in pest management operations, a letter or request for certification or recertification is forwarded through proper channels to the designated certifying official.

When requesting initial certification for an individual the body of the letter should contain the following information:

- Category of certification requested.
- Name of individual (last name - first name - middle initial).
- Rank/grade.
- Social security number.
- Training accomplishments within the career field.
- Length of time performed in the career field.

This letter should be signed by the Base Civil Engineer, and copies of recent training certificates related to pest management received by the individual should be forwarded as attachments with the letter.

Recertification of individuals who presently hold a certificate of competency is required every 2 years if performing in either of the capacities previously mentioned.

Requests for recertification are prepared and processed in the same manner as for certification, with only the contents of the letter body changed to provide the following information:

- Category of certification requested.
- Name of individual (last name - first name - middle initial).
- Rank.
- Social security number.
- Present certification number and expiration date.
- Recent career field training accomplishments.

Upon receipt of certification or recertification request, the certifying official will make the determination as to approve or disapprove the request. If the request is approved on its own merits, a certificate of competency will be forwarded to the individual; however, if the certifying official needs further justification, instructions identifying additional actions to be taken will be forwarded.

Beginning 1 October 1977, testing will be required of all individuals desiring initial certification or recertification in order to comply with Public Law 92-516, Federal Environmental Pesticide Control Act (FEPCA) of 1972.

A roster listing each certified individual, certification number, and expiration date must be maintained within civil engineering to act as a reminder and to identify certified individuals to other concerned individuals.

Exercises (228):

1. What individuals must possess an AF Form 483, Certificate of Competency?

2. All individuals who disperse pesticides must be recertified every __________________________.

3. State the purpose of AF Form 483.

4. The roster that identifies all personnel who possess an AF Form 483 in pest management sections is maintained in ________________________________.

5. When an individual is thought to be properly prepared to be certified, what is the first step to be taken to obtain certification?

6. List the information that must be provided in requesting initial certification.

229. State the purpose, use, and disposition of AF Form 2467.

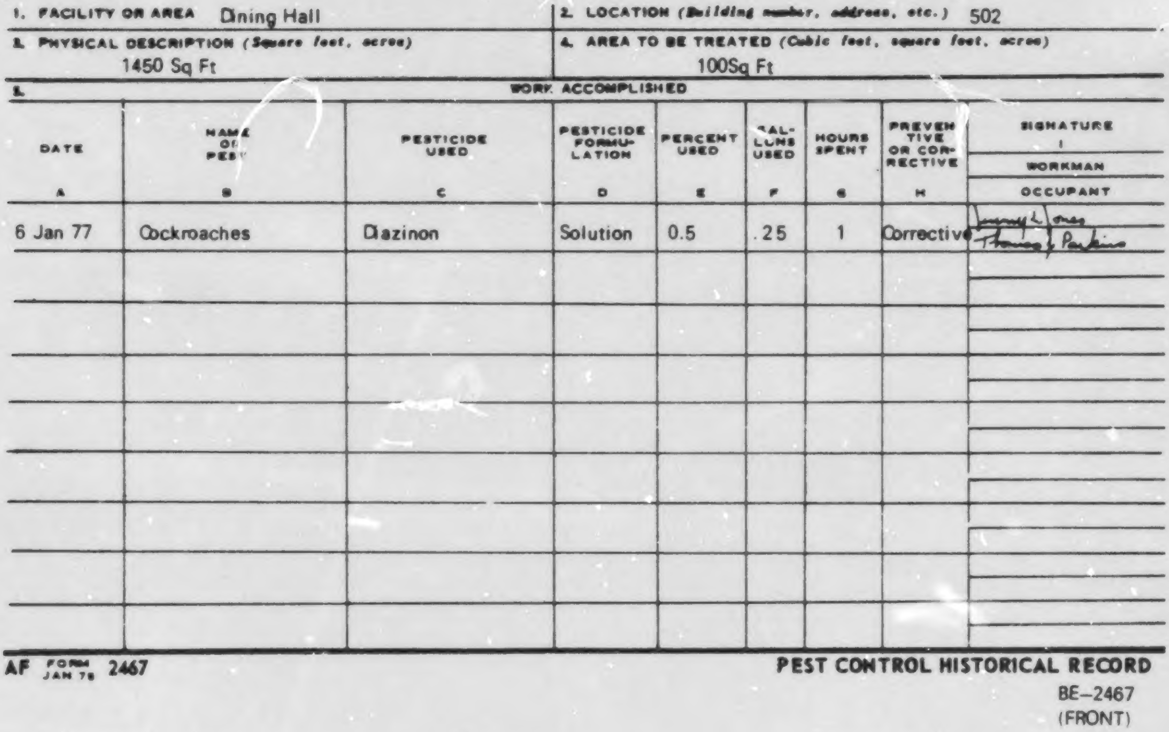
AF Form 2467, Pest Control Historical Record. This form must be maintained on all major facilities that require repetitive applications of pesticides, such as dining halls and cafeterias. The use of this form should not be considered restricted to dining halls and cafeterias only, because it should be maintained on each facility or area that has required frequent pesticide applications.

Purpose. The primary purpose of this form is to maintain a record of pest problems and the types of pesticides applied to manage the pests within a particular facility to determine whether variations in pesticides are needed to avoid resistance to pesticides.

The AF Form 2467 must be completed each time pesticides are applied to the type of facility or area previously identified. Figure 2-23 shows an example of the AF Form 2467 and the type of information entered in each of the blocks.

It is suggested that an AF Form 2467 be maintained for each facility on the installation. This will provide a complete record of pesticide treatment for each facility, identify the individual who performed each treatment, and serve as proof of treatment when signed by an occupant of the facility. This will eliminate the need of producing and reproducing local forms or logs that serve the same purpose.

Disposition. When both sides of the form have been completed, initiate a new form and transcribe the information contained in blocks 1 through 4 of the completed form to the new one; file the completed form behind the new form. These forms must be maintained on file for a period of 5 years; therefore, a card cannot be destroyed until the last entry made on the form exceeds 5 years.



1. FACILITY OR AREA Dining Hall

2. LOCATION (Building number, address, etc.) 502

3. PHYSICAL DESCRIPTION (Square feet, acres) 1450 Sq Ft

4. AREA TO BE TREATED (Cubic feet, square feet, acres) 100Sq Ft

5. WORK ACCOMPLISHED

DATE A	NAME OF PEST B	PESTICIDE USED C	PESTICIDE FORMULATION D	PERCENT USED E	GALLONS USED F	HOURS SPENT G	PREVENTIVE OR CORRECTIVE H	SIGNATURE I WORKMAN OCCUPANT
6 Jan 77	Cockroaches	Diazinon	Solution	0.5	.25	1	Corrective	Jimmy L. Jones Thomas J. Perkins

AF FORM JAN 76 2467 PEST CONTROL HISTORICAL RECORD

BE–2467
(FRONT)

Figure 2-23. AF Form 2467, Pest Control Historical Record.

Exercise (229):

1. The AF Form 2467 is required to be maintained on all major facilities that ____________________.

2. The primary purpose for maintaining an AF Form 2467 on each major facility is to prevent pests from becoming __________________.

3. What is the frequency for recording information pertaining to the treatment of a major facility on an AF Form 2467?

4. List the suggested reasons for maintaining an AF Form 2467 on each facility.

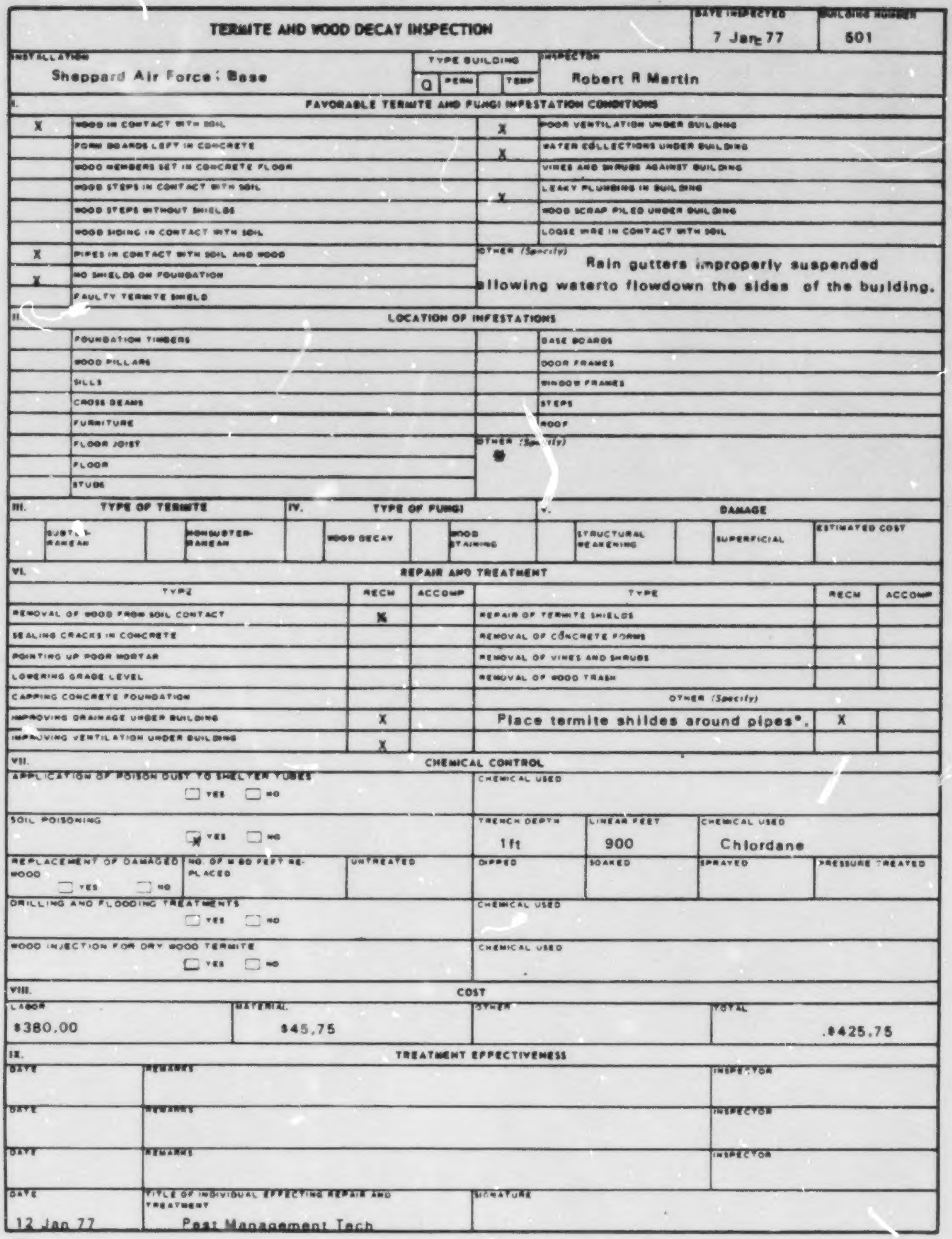
5. When can AF Form 2467 with the last entry date of 15 November 1974 be destroyed?

230. State the purpose, use, and disposition of the DD Form 1070 and complete the form that is provided from information contained in a given situation.

DD Form 1070, Termite and Wood Decay Inspection. A DD Form 1070 must be maintained for each facility that is constructed completely or partly of wood on all Federal installations. This includes virtually all facilities, regardless of preventive measures used in the construction.

Purpose. Each facility that is constructed completely or partly of wood must be inspected for signs indicating the presence of structural pests and conditions within and around the facility that would be conducive to structural pests. *These inspections must be accomplished no less often than annually for each facility and should* be inspected at least semiannually. This form serves as a record of these inspections and provides information pertaining to building conditions and actions taken.

Completion procedures. The DD Form 1070 is shown in figure 2-24 with entries provided to illustrate its use. This form is not difficult to fill in; but, you must insure that the entries made on the form indicate true conditions found during the inspection of the facility. You must also insure that recommendations are annotated correctly, and when recommendations or other actions have been accomplished, the form must be annotated to reflect these actions.



TERMITE AND WOOD DECAY INSPECTION

DATE INSPECTED	7 Jan 77
BUILDING NUMBER	501
INSTALLATION	Sheppard Air Force Base
TYPE BUILDING	Q PERM ☐ TEMP
INSPECTOR	Robert R Martin

I. FAVORABLE TERMITE AND FUNGI INFESTATION CONDITIONS

X	WOOD IN CONTACT WITH SOIL	X	POOR VENTILATION UNDER BUILDING
	FORM BOARDS LEFT IN CONCRETE	X	WATER COLLECTIONS UNDER BUILDING
	WOOD MEMBERS SET IN CONCRETE FLOOR		VINES AND SHRUBS AGAINST BUILDING
	WOOD STEPS IN CONTACT WITH SOIL	X	LEAKY PLUMBING IN BUILDING
	WOOD STEPS WITHOUT SHIELDS		WOOD SCRAP PILED UNDER BUILDING
	WOOD SIDING IN CONTACT WITH SOIL		LOOSE WIRE IN CONTACT WITH SOIL
X	PIPES IN CONTACT WITH SOIL AND WOOD	OTHER *(Specify)*	Rain gutters improperly suspended allowing waterto flowdown the sides of the building.
X	NO SHIELDS ON FOUNDATION		
	FAULTY TERMITE SHIELD		

II. LOCATION OF INFESTATIONS

	FOUNDATION TIMBERS		BASE BOARDS
	WOOD PILLARS		DOOR FRAMES
	SILLS		WINDOW FRAMES
	CROSS BEAMS		STEPS
	FURNITURE		ROOF
	FLOOR JOIST	OTHER *(Specify)*	*
	FLOOR		
	STUDS		

III. TYPE OF TERMITE				IV. TYPE OF FUNGI				V. DAMAGE				
	SUBTERRANEAN		NONSUBTERRANEAN		WOOD DECAY		WOOD STAINING		STRUCTURAL WEAKENING		SUPERFICIAL	ESTIMATED COST

VI. REPAIR AND TREATMENT

TYPE	RECM	ACCOMP	TYPE	RECM	ACCOMP
REMOVAL OF WOOD FROM SOIL CONTACT	X		REPAIR OF TERMITE SHIELDS		
SEALING CRACKS IN CONCRETE			REMOVAL OF CONCRETE FORMS		
POINTING UP POOR MORTAR			REMOVAL OF VINES AND SHRUBS		
LOWERING GRADE LEVEL			REMOVAL OF WOOD TRASH		
CAPPING CONCRETE FOUNDATION			OTHER *(Specify)*		
IMPROVING DRAINAGE UNDER BUILDING	X		Place termite shildes around pipes*.	X	
IMPROVING VENTILATION UNDER BUILDING	X				

VII. CHEMICAL CONTROL

APPLICATION OF POISON DUST TO SHELTER TUBES ☐ YES ☐ NO	CHEMICAL USED			
SOIL POISONING ☒ YES ☐ NO	TRENCH DEPTH 1ft	LINEAR FEET 900	CHEMICAL USED Chlordane	
REPLACEMENT OF DAMAGED WOOD ☐ YES ☐ NO | NO. OF M BD FEET REPLACED | UNTREATED	DIPPED	SOAKED	SPRAYED	PRESSURE TREATED
DRILLING AND FLOODING TREATMENTS ☐ YES ☐ NO	CHEMICAL USED			
WOOD INJECTION FOR DRY WOOD TERMITE ☐ YES ☐ NO	CHEMICAL USED			

VIII. COST

LABOR	MATERIAL	OTHER	TOTAL
$380.00	$45,75		.$425.75

IX. TREATMENT EFFECTIVENESS

DATE	REMARKS	INSPECTOR

DATE	TITLE OF INDIVIDUAL EFFECTING REPAIR AND TREATMENT	SIGNATURE
12 Jan 77	Pest Management Tech	

*

1. Repair plumbing
2. Repair rain gutters
3. Apply chemical to soil on each side of foundation

Figure 2-24 DD Form 1070, Termite and Wood Decay Inspection.

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Looking at figure 2-24, you will notice that the top portion is used to identify the number, type, and location of the facility; the date of the inspection; and the inspector's name. If you happen to be the inspector, you are responsible for the information entered or not entered on this form; therefore, the true conditions found inside, outside, and beneath a facility must be accurately and completely recorded.

Part I is used to indicate conditions within and around the facility that are conducive to structural pests' infestations. As an example, Xs have been placed in this part to identify the conditions found during an inspection conducted on a facility, and an additional comment has been entered in the block identified as "other."

Part II is used to identify the location where structural pests are actually found during the time of the inspection. If you will observe, no Xs have been placed in any of the blocks in this part, which indicates there were no structural pests present at the time the inspection was conducted.

Parts III and IV are used to identify the type of termite and fungi, respectively, found during the inspection. Since there were no termites or fungi observed, no entries were made in any of the blocks in either of these parts.

If termites or fungi had been observed, then part V would have been used to identify the type of damage incurred by the pests and the estimated cost of the damage.

Part VI is used to reflect repair and treatment recommendations and the actual accomplishment of recommendations. Still looking at figure 2-24, observe the entries in part VI and compare them with the entries in part I. *Note that part VI should reflect recommendations to correct the conditions annotated in part I in all possible situations,* as has been done in the illustration provided. It is the inspector's responsibility to initiate action to accomplish recommendations by initiating service calls and/or job orders as applicable.

As you can see, an asterisk has been placed in the portion identified as "Other" to denote that additional recommendations are identified elsewhere on the form (in this case, on the bottom) due to the lack of sufficient space. These additional recommendations are used to further support the findings identified in part I. Note footnote number 3. This was added as a recommendation to correct the situation identified in part I in reference to "no shields on foundation." Since it would be almost impossible and very impractical to install termite shields after the building has already been constructed, the most practical thing to do is treat the soil on both sides of the foundation, if not previously accomplished, which applies in this situation.

Upon completion of each recommended action, the form must be annotated in part VI to reflect the actual accomplishment of recommended actions.

Part VII is used to identify the type, quantity, and method of chemical control implemented to manage termites and/or fungi, and is also used to identify measures taken to correct damaged portions of the facility.

As you have probably noticed in viewing figure 2-24, entries have been made to indicate that soil poisoning was accomplished and that chlordane was applied to a trench 1 foot in depth and 900 linear feet.

Part VIII is used to identify the cost of accomplishing recommended actions. Entries are made to reflect the cost of materials, labor, and other possible expenditures as shown in the illustration.

Part IX is used to identify the date that chemical treatment was accomplished and the person who was responsible for the treatment.

This information is entered in the bottom blocks as shown in figure 2-24. The remaining blocks in this part are used for inspections accomplished after treatment to record treatment effectiveness.

Disposition. As outlined in AFM 12-50, Table 91-5, DD Forms 1070 for each type of facility previously described must be maintained indefinitely and must not be destroyed unless building is disposed of or installation is inactivated and dropped from real property accounts.

Exercises (230):

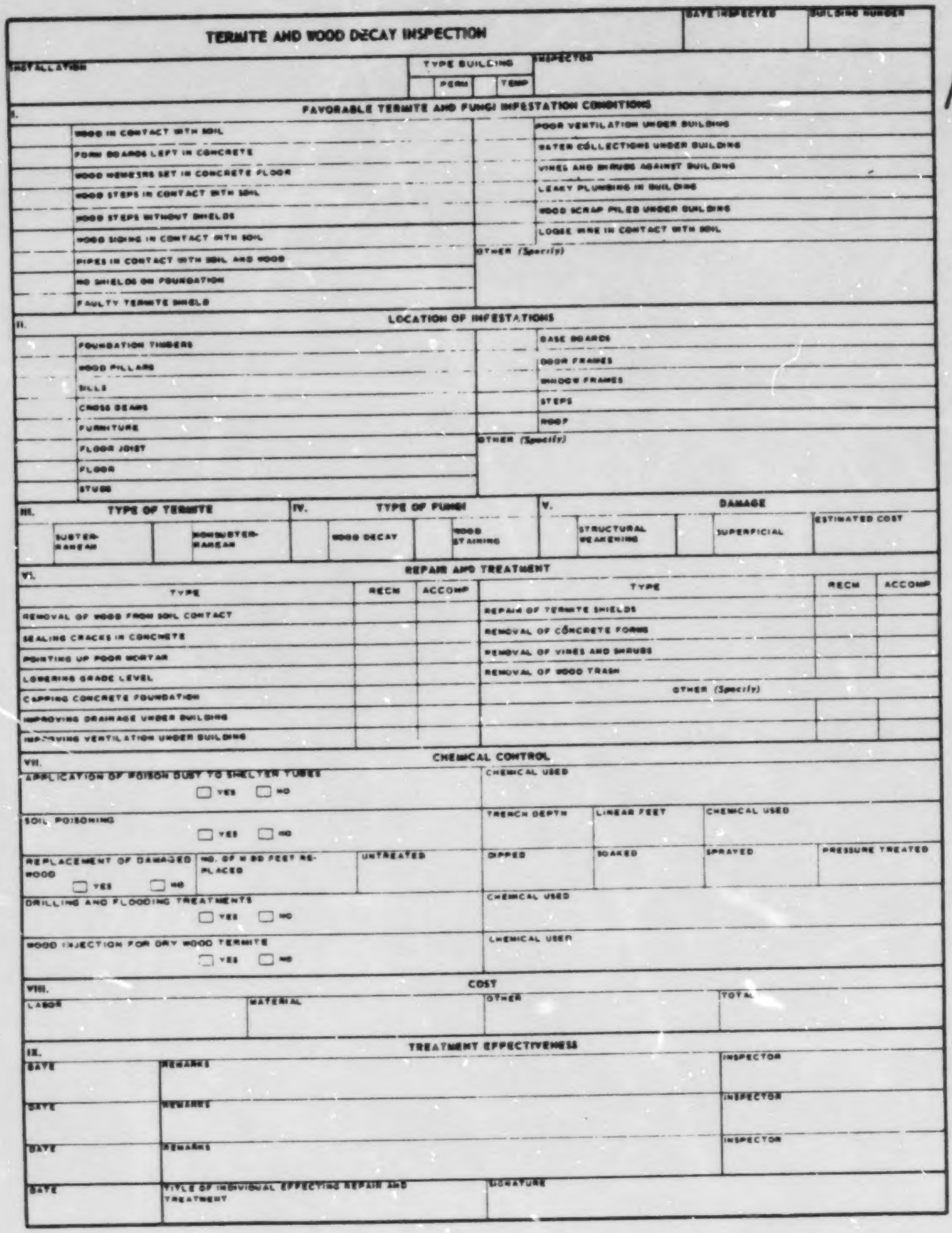
1. What facilities require that a DD Form 1070 be maintained?

2. How often must facilities be inspected?

3. What is the purpose of the DD Form 1070?

4. When can the DD Form 1070 be destroyed?

5. Using the illustrated DD Form 1070 that is provided in figure 2-25, properly complete the form by entering the appropriate information provided below in the applicable spaces on the form.



TERMITE AND WOOD DECAY INSPECTION

DATE INSPECTED	BUILDING NUMBER	
INSTALLATION	TYPE BUILDING ☐ PERM ☐ TEMP	INSPECTOR

I. FAVORABLE TERMITE AND FUNGI INFESTATION CONDITIONS

☐	WOOD IN CONTACT WITH SOIL	☐	POOR VENTILATION UNDER BUILDING
☐	FORM BOARDS LEFT IN CONCRETE	☐	WATER COLLECTIONS UNDER BUILDING
☐	WOOD MEMBERS SET IN CONCRETE FLOOR	☐	VINES AND SHRUBS AGAINST BUILDING
☐	WOOD STEPS IN CONTACT WITH SOIL	☐	LEAKY PLUMBING IN BUILDING
☐	WOOD STEPS WITHOUT SHIELDS	☐	WOOD SCRAP PILED UNDER BUILDING
☐	WOOD SIDING IN CONTACT WITH SOIL	☐	LOOSE WIRE IN CONTACT WITH SOIL
☐	PIPES IN CONTACT WITH SOIL AND WOOD	OTHER *(Specify)*	
☐	NO SHIELDS ON FOUNDATION		
☐	FAULTY TERMITE SHIELD		

II. LOCATION OF INFESTATIONS

☐	FOUNDATION TIMBERS	☐	BASE BOARDS
☐	WOOD PILLARS	☐	DOOR FRAMES
☐	SILLS	☐	WINDOW FRAMES
☐	CROSS BEAMS	☐	STEPS
☐	FURNITURE	☐	ROOF
☐	FLOOR JOIST	OTHER *(Specify)*	
☐	FLOOR		
☐	STUDS		

III. TYPE OF TERMITE		IV. TYPE OF FUNGI		V. DAMAGE		
☐ SUBTERRANEAN	☐ NONSUBTERRANEAN	☐ WOOD DECAY	☐ WOOD STAINING	☐ STRUCTURAL WEAKENING	☐ SUPERFICIAL	ESTIMATED COST

VI. REPAIR AND TREATMENT

TYPE	RECM	ACCOMP	TYPE	RECM	ACCOMP
REMOVAL OF WOOD FROM SOIL CONTACT			REPAIR OF TERMITE SHIELDS		
SEALING CRACKS IN CONCRETE			REMOVAL OF CONCRETE FORMS		
POINTING UP POOR MORTAR			REMOVAL OF VINES AND SHRUBS		
LOWERING GRADE LEVEL			REMOVAL OF WOOD TRASH		
CAPPING CONCRETE FOUNDATION			OTHER *(Specify)*		
IMPROVING DRAINAGE UNDER BUILDING					
IMPROVING VENTILATION UNDER BUILDING					

VII. CHEMICAL CONTROL

APPLICATION OF POISON DUST TO SHELTER TUBES ☐ YES ☐ NO		CHEMICAL USED		
SOIL POISONING ☐ YES ☐ NO		TRENCH DEPTH	LINEAR FEET	CHEMICAL USED
REPLACEMENT OF DAMAGED WOOD ☐ YES ☐ NO	NO. OF W BD FEET REPLACED	UNTREATED	DIPPED	SOAKED	SPRAYED	PRESSURE TREATED
DRILLING AND FLOODING TREATMENTS ☐ YES ☐ NO		CHEMICAL USED		
WOOD INJECTION FOR DRY WOOD TERMITE ☐ YES ☐ NO		CHEMICAL USED		

VIII. COST

LABOR	MATERIAL	OTHER	TOTAL

IX. TREATMENT EFFECTIVENESS

DATE	REMARKS	INSPECTOR
DATE	REMARKS	INSPECTOR
DATE	REMARKS	INSPECTOR
DATE	TITLE OF INDIVIDUAL EFFECTING REPAIR AND TREATMENT	SIGNATURE

Figure 2-25. DD Form 1070, Termite and Wood Decay Inspection (objective 228, exercise 5).

On 14 January 1977, Building 302 at Mitchell AFB was inspected for termite and wood decay by Self Alone. This building happens to be a permanent building but is several years old.

The inspection revealed superficial damage to the rafters caused by dry-wood termites that had entered through deteriorated screens over the attic vents. There were no other conditions favoring termite or fungi infestation.

After a thorough inspection and extreme consideration, it was determined that the screens for the vents must be replaced and the rafters injected with pentachlorophenol to arrest further damage.

The total cost of corrective measures was $330. The screen and chemical cost $73, and a special item of equipment to do the job cost $30.

After the treatment was performed it was reinspected on 17 January 1977 by Self Along, who is the section supervisor.

231. Provided with applicable information concerning the AF Form 290 and a case situation, stated completion procedures and purpose of the AF Form 290 and complete the form that is provided.

AF Form 290, Transcript for Pest Report. As outlined in AFR 91-21, this report is to be prepared on a daily basis by pest management personnel.

Purpose. The AF Form 290 (fig. 2-26) is used for recording daily pest management activities and is the source document for creating a Pest File, which is used to provide a complete record of all preventive and corrective pest management programs.

Completion procedures. Preparation of the AF Form 290 is accomplished by transcribing *longhand information* pertaining to pest management activities into codes and abbreviations on a daily basis to provide keypunch capability.

For installations that utilize the B3500 computer system, which is the majority of installations, instructions for completing the AF Form 290 are provided in AFR 91-21, *Pest Management Programs;* AFM 171-200, *The Base Engineer Automated Management System;* and AFM 300-4, *Data Elements and Codes.* Codes and specific instructions are contained in AFM 300-4, Volumes IV, VI, and XII and AFM 171-200, Part 10.

This portion of the CDC should give you a better understanding of the procedures used in completing the AF Form 290, for use with the B3500 computer system, by combining information extracted from AFR 91-21 and AFM 300-4.

The information entered on this form must reflect all pest management activities accomplished within a day's time. Normally, individual activities are recorded on AF Forms 2467 or in a log book; then at the end of the day these activities are categorically separated and compiled. This compiled information is then transcribed onto the AF Form 290.

Since the information contained on this form is used for keypunch operations, the information must be coded and separated into three sections which identify the information as pertaining to Pest Control Operations, Pest Surveys, or Herbicide Control.

This coded information is then keypunched onto cards identified as Pest detail cards (1/80, 2/80, and 3/80). The Pest detail card 1/80 is the Pest control operation card that contains all the information pertaining to arthropod pest control operations except for the hours spent on surveys. The PEST detail card 2/80 is the Pest survey card which reflects the hours expended conducting surveys during a day's time. The PEST detail card 3/80, herbicide control card, contains all information pertaining to herbicide control operations with the exception of the hours expended on surveys.

In order to show how the information concerning daily pest management activities is transcribed and entered on a typical AF Form 290, a case situation will be utilized and illustrations of the handscribed information for the situation will be provided.

Case Situation 2-1

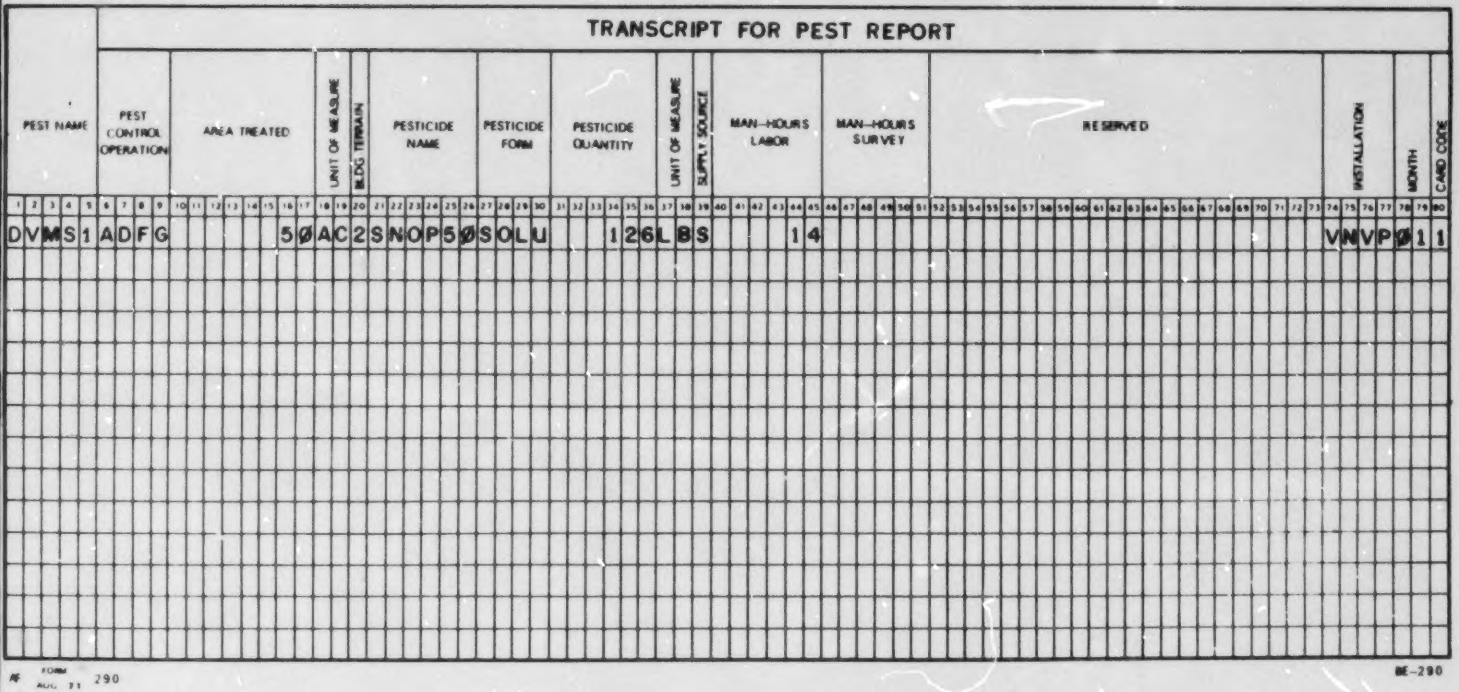
On 12 January 1977, you and another pest manager within the section conducted a fogging operation to control adult mosquitoes. During this operation, you fogged 50 acres of the installation using 240 gallons of a 6-percent malathion-oil solution. This solution was prepared from a 57-percent E/C (emulsifiable concentrate) malathion and a number 4 grade fuel oil. Fogging the 50 acres took 6 hours, which means that a total of 14 hours was expended during the actual performance; and prior to this, 3 hours were expended in conducting surveys.

Refer to figure 2-26 and study it carefully, because this illustration of the completed AF Form 290 will be utilized throughout this unit of instruction. Note the manner in which the form is separated into *data elements* to identify the information (pest name, pest control operation, etc.) that is entered in the *columns* below the data element.

Since portions of the information contained in the case situation must be coded, as previously stated, codes have been extracted from AFM 300-4 and are provided to you in tables 2-1 through 2-3.

Looking at figure 2-26, you can see that the first data element to be entered on this form is the Pest Name. The pest that was identified in the case situation was adult mosquitoes; therefore, referring to table 2-1, you can see that adult mosquitoes are identified by the data code DVMS 1. This code is entered in columns 1 through 5 on the AF Form 290.

The next data element to be entered is the Pest Control Operation, which was identified as a fogging operation to control adult mosquitoes. Scanning over the pest control operation data codes provided in table 2-2, you will find the pest control operation Adulticiding Fog is identified by the data code ADFG. This code has been entered in columns 6 through 9 on the illustrated AF Form 290.



TRANSCRIPT FOR PEST REPORT

PEST NAME	PEST CONTROL OPERATION	AREA TREATED	UNIT OF MEASURE	BLDG TERRAIN	PESTICIDE NAME	PESTICIDE FORM	PESTICIDE QUANTITY	UNIT OF MEASURE	SUPPLY SOURCE	MAN-HOURS LABOR	MAN-HOURS SURVEY	RESERVED	INSTALLATION	MONTH	CARD CODE
1–5	6–9	10–17	18–19	20	21–26	27–30	31–36	37–38	39	40–45	46–51	52–73	74–77	78–79	80
DVMS1	ADFG	50	AC	2	SNOP50	SOLU	126	LB	S	14			VNVP	01	1

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Figure 2-26. AF Form 290, Transcript for Pest Report (example of pest control operation entries).

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TABLE 2-1
PEST NAME DATA CODES

Data Codes	Data Items and Explanations:	Data Item Name
	Attacking Vegetation Pests	
AVBB0	Bark Beetles	BARKBEETS
AVBR0	Borers	BORERS
AVDJ0	Defoliators and Juice-Sucking	DEFOLJUSU
AVSR0	Soil and Root Infesting	SOIL-ROOT
AVTS0	Twig and Stem Girdlers	TWIG-STEM
	Disease Vector Pests	
	Bugs	
DVBG1	Bedbugs	BEDBUGS
DVBG2	Cockroaches	COCKROACH
DVBG3	Fleas	FLEAS
DVBG4	Lice	LICE
DVBG5	Mites	MITES
DVBG6	Ticks	TICKS
	Flies-Biting	
DVFB1	Black	BLACK-FLY
DVFB2	Culicoides	CULICOIDE
DVFB3	Phlebotomus	PHLEBOTOM
DVFB4	Stable	STABLEFLY
DVFB5	Tabanid	TABANID
	Flies-Nonbiting	
DVFN1	Blow	BLOW-FLY
DVFN2	House-Adult	H-ADULT
DVFN3	House-Larval	H-LARVAL
DVFN4	Midges and GNATS	MIDGEGNAT
DVFN5	Psychodid	PSYCHODID
	Mosquitoes	
DVMS1	Adult	MOSADULT
DVMS2	Larvae	MOSLARVA
DVZZ0	Other Disease Vector Pests	ODSVCPEST
	Miscellaneous Pests	
MPBD0	Birds	BIRDS
MPNT0	Nematodes	NEMATODES
	Rodents	
MPRD1	Mice	MICE
MPRD2	Rats	RATS
MPRD3	Other	OTHRODENT
MPSS0	Snails and Slugs	SNAILSLUG
MPZZ0	Other	OMISCPEST
	Nuisance Pests	
NPAN0	Ants	ANTS
NPCK0	Crickets	CRICKETS
NPEW0	Earwigs	EARWIGS
NPFS0	Firebrats and Silverfish	FIBRSILFH
NPZZ0	Other	
	Stored Products Insects	
SPFA0	Pests of Food of Animal Origin	FODANIORI
SPFF0	Pests of Fibers and Fabrics of Animal Origin	FIBFABANI
SPFV0	Pests of Legumes, Dried Fruits, and Vegetables	LEGFRUVEG
SPGC0	Pests of Grains and Cereal Products	GRAINCEAL
	Structural Pests	
	Marine Borers	
STMB1	Crustaceans	CRUSTACEA
STMB2	Molluscs	MOLLUSCS
STOW0	Other Wood Destroying Insects	OWDINSECT
STPB0	Powder Post Beetles	PDPTBEETS
STPP0	Powder Post Borers	PDPTBORER
	Termites	
STTM1	Dampwood	DAMPWOOD
STTM2	Drywood	DRYWOOD
STTM3	Subterranean	SUBTTERRAN
STWD0	Wood Destroying Fungi	WDESFUNGI
	Venomous Arthropods	
VACP0	Centipedes	CENTIPEDE
VASC0	Scorpions	SCORPIONS
VASP0	Spiders	SPIDERS
VAUC0	Urticating	URTICATIN
VAWB0	Wasps and Bees	WASP/BEES
	Weed Pests	
WPAT0	Aquatic	AQUATIC
WPBL0	Broadleaf	BROADLEAF
WPGS0	Grassy	GRASSY
WPMX0	Mixed	MIXED
WPWD0	Woody	WOODY

TABLE 2-2
PEST CONTROL OPERATION DATA CODES

Data Codes	Data Items and Explanations:	Data Item Name
	Adulticiding	
ADDS	Dust	ADULTICID-DUST
ADFG	Fog	ADULTICID-FOG
ADMS	Mist	ADULTICID-MIST
ADZZ	Other	ADULTICID-OTHER
	Insects Attacking Vegetation Operation	
AVAT	Area Treatment (Including Shrubs)	AREA-TREATMENT
AVTS	Trees Sprayed or Treated	TREES-SPRAYED
	Baiting	
BTBD	For Birds	BAITING-BIRDS
BTIN	For Insects	BAITING-INSECTS
BTRD	For Rodents	BAITING-RODENT
	Disease Vector and Nuisance Pests	
DNDT	Ditching (New and Maintenance)	DITCHING
DNLF	Land Fill	LAND-FILL
	Dip-Soak Treatments	
DSLM	Lumber	LUMBER
DSPL	Pallets	PALLETS
	Fumigation	
FMAT	Atmospheric	ATMOSPHERIC
FMVA	Vacuum	VACUUM
	Inter-Space Treatment	
ISHH	Mist, Gas, Other: Not to include household aerosol dispensers	INTER-SPACE-TRT
	In-Place Treatments	
ITPI	Pilings	PILING-IN-PLACE
ITPL	Poles	POLES-IN-PLACE
ITST	Structural	STRUCTURAL
	Larviciding	
LVDS	Dust	LARVICID-DUST
LVGR	Granules	LARVICID-GRANS
LVMS	Mist	LARVICID-MIST
LVZZ	Other	LARVICID-OTHER
	Pressure Treated (Preserved) Components Installed	
PTPI	Piling	PILING-PRS-TRTD
PTPL	Poles	POLES-PRS-TRTD
PTWL	Wood and Lumber	WOOD-LUMBER
	Residual Treatments	
RTDG	Dust or Granules	RESIDUAL-DUSTS
RTSP	Sprays	RESIDUAL-SPRAYS
	Stored Products	
SPRT	Residual Treatments	RESIDUAL-TREAT
SPST	Space Treatments	SPACE-TREATMENT
	Structural	
STFM	Fumigation	FUMIGATION
STSF	Surface	SURFACE
STST	Soil Treatment	SOIL-TREATMENT
STTR	Trench	TRENCH

The data element Area Treated contains eight columns for entering the total number of square feet or acres treated. Although there are eight columns provided for this data element, all do not have to be utilized. Since this data element requires the entry of a number or numbers, you would only utilize the columns required for entering the total number of digits that appear in the number of square feet or acres treated.

NOTE: The number of acres or square feet entered for this data element must be whole numbers. Parts of acres or square feet cannot be entered.

Referring to the case situation, you will find that 50 acres were treated. Therefore, this number would be entered in columns 16 and 17, as illustrated in figure 2-26. (NOTE: All zeros must be slashed in order to separate zeros from the letter "O"; therefore, the letter "O" should never be slashed.)

The fourth data element on the AF Form 290 is the Unit of Measure. The unit of measure must be entered as SF (square feet) for all indoor treatments or AC (acres) for all outdoor treatments. "AC" has been entered in columns 18 and 19, respectively (fig. 2-26), to reflect that acres were treated in the case situation provided.

The data element appearing on the AF Form 290 as Building Terrain is used for identifying where the treatment was performed. The number "1" or "2" must be entered in column 20. Since the treatment performed in case situation 2-1 occurred outdoors, the number "2" has been entered in column 20 of the form illustrated in figure 2-26. NOTE: When "AC" is entered in columns 18 and 19, the number "2" must be entered in column 20. If "SF" has been entered in columns 18 and 19, the number "1" must be entered in column 20.

The data element Pesticide Name is used to identify the pesticide used in treatment. The name of the pesticide must be coded (pesticide name data code provided in table 2-3), and the data code must be entered in columns 21 through 26, as shown in figure 2-26. As you can see by the information provided in table 2-3, the data code *SNOP50* identifies the pesticide used in case situation 2-1 as being malathion.

SPECIAL NOTE: To support a previous note made while discussing the Area Treated data element, notice the distinction made between the letter "O" and the number zero "0" in the Pesticide Name data code.

Referring again to case situation 2-1, the pesticide form used in the treatment for adult mosquitoes was a solution prepared from malathion E/C and fuel oil. Viewing table 2-4, you will find that a solution is identified with the data code SOLU. The pesticide form data code must be entered in columns 27 through 30, as illustrated in figure 2-26, which identifies the data element Pesticide Form.

In the data element identified as Pesticide Quantity (columns 31 through 36), you must enter the total pounds of active ingredient contained in the total amount of pesticide formulation dispersed. This information must be in whole numbers (complete pounds) because the computer will not accept portions of a pound; or in other words, you cannot use ounces.

Recording the actual amount of active ingredient in pounds is the most difficult task involved in completing the AF Form 290 and is often reported erroneously due to the fact that many pest managers are not aware of the procedures used in determining the pounds of active ingredient contained in a given quantity of finished product. Erroneous reporting will occur more often when pesticide labels do not furnish information pertaining to the pounds of active ingredients contained in each gallon of pesticide than those that do.

TABLE 2-3
PESTICIDE NAME DATA CODES

Data Codes	Data Items and Explanations:	Data Item Name
NAOL20	Summer	SUMMER
NAPY00	Pyrethrum	PYRETHRYM
NAZZ00	Other Natural Organic Insecticides	ONATORGIN
	Rodenticides	
RDAC00	Anticoagulants	ANTICOAGU
RDCC00	Calcium Cyanide	CALCYANDE
RDSM00	Sodium Monofluoracetate	SODMONOFD
RDSN00	Strychnine	STRYCHIN
RDZP00	Zinc Prosphide	ZNPHOSPDE
RDZZ00	Other Rodenticides	ORODENTID
	Repellants	
RPAL00	All Types of Repellants	ALLREPELL
	Synthetic Organic	
	Carbamates	
SNCB10	Baygon	BAYGON
SNCB20	Sevin	SEVIN
	Chlorinated Hydrocarbons	
SNCH10	Aldrin	ALDRIN
SNCH20	Chlordane	CHLORDANE
SNCH30	DDT	DDT
SNCH40	Dieldrin	DIELDRIN
SNCH50	Heptachlor	HEPTACHLO
SNCH60	Kepone (include Mirex)	KEPONE
SNCH70	Lindane	LINDANE
SNCH80	Pentachlorophenol	PENTACHLO
SNCH99	Other Chlorinated Hydrocarbons	OCHLORHYD
	Organic Phosphates	
SNOP10	DDVP	DDVP
SNOP20	Diazinon	DIAZINON
SNOP30	Dibrom (Naled)	DIBROM
SNOP40	Fenthion	FENTHION
SNOP50	Malathion	MALATHION
SNOP99	Other Organic Phosphates	OORGPHOSP
SNOS00	Other Sulfur Compounds	ORGSULFUR
SNOT00	Organic Thiocyanates	ORGTHIOCY
	Uncombined Herbicides	
	Aquatic	
UHAT1-	Copper Sulfate	COP-SULFA
UHAT20	Diquat	DIQUAT
	Contact	
UHCT10	Ammonium Sulfamate	AM-SULFAM
UHCT20	Arsenicals, Organic	ARSEN-ORG
UHCT30	Arsenite, Sodium	ARSTE-SOD
UHCT40	Dinitro Compounds	DINITRO
UHCT50	Oils, Herbicidal	OILSHERBI
UHCT60	Paraquat	PARAQUAT
UHCT70	Pentachlorophenol	PENTACHLO
	Growth Regulators	
UHGR10	Amitrole	AMITROLE
UHGR20	Atrazine	ATRAZINE
UHGR30	Dalapon	DALAPON
UHGR40	Maleic Hydrazide	MALHYDRAZ
UHGR50	Silvex	SILVEX
UHGR60	2, 4-D	24D
UHGR70	2, 4, 5-T	245T

TABLE 2-3
PESTICIDE NAME DATA CODES (Cont'd.)

Data Codes	Data Items and Explanations:	Data Item Name
	Combination Herbicides	
	Growth Regulators-Contact	
CHGC00	Arsenicals, Organic-2, 4-D	ARSORG24D
	Growth Regulators	
CHGR10	Dalapon-Silvex	DALSILVEX
CHGR20	Dalapon-2, 4, 5-T	DALAP245T
CHGR30	2, 4-D, 2, 4, 5-T	24D245T
	Growth Regulators-Soil	
CHGS10	Amitrole-Simazine	AMISIMAZI
CHGS20	Borate-2, 4-D	BORATE24D
	Soil Sterilants	
CHSS10	Borate-Monuron	BORMUNURO
CHSS20	Bromacil-Borate	BRMCILBOR
CHSS30	Bromacil-Borate-Chlorate	BRMBORCHL
CHSS40	Chlorate-Borate	CHLBORATE
CHSS50	Chlorate-Borate-Monuron	CHLBORMON
CHSS60	Fenuron-TCA	FUNUROTCA
CHSS70	Monuron-TCA	MONUROTCA
CHZZ00	Other Combination Herbicides	OCOMBHERB
	Fumigants	
FMAP00	Aluminum Phosphide	ALPHOS
FMCB00	Carboxide	CARBO-IDE
FMHA00	Hydrocyanic Acid	HYDROCYAN
FMMB00	Methyl Bromide	MEBROMIDE
FMPD00	Paradichlorobenzene	PARADICHL
FMSL00	Soil Fumigants	SOILFUMIG
FMSU00	Sulfuryl Fluoride	SULFURYFL
FMZZ00	Other Fumigants	OFUMIGANT
	Inorganic Insecticides	
	Arsenicals	
INAR10	Lead Arsenate	LDARSENAT
INAR20	Paris Green	PRISGREEN
INAR30	Sodium Arsenite	SODARSENT
INAR99	Other Arsenical Compounds	OARSENCMP
	Miscellaneous Inorganic Insecticides	
INMS10	Copper Naphtenate	COPPERNAP
INMS20	Copper Sulfate Formulations	COPERSULF
INMS30	Silica Aerogels	SILICAERO
INMS99	Other Miscellaneous Inorganic Insecticides	OINORGANI
	Sulfur	
INSL10	Dusting and Wettable Sulfur	DUSWETSUL
INSL20	Lime Sulfur	LIMESULFU
	Miscellaneous Chemical Compounds	
MSAT00	Attractants	ATTRACTS
MSFG00	Fungicides	FUNGICIDE
MSML00	Mollescicides	MOLCIDES
MSZZ00	Other Chemical Compounds	OCHEMCOMP
	Natural Organic Insecticides	
NAAL00	Allethrin	ALLETHRIN
NACS00	Creosote	CREOSOTE
	Oils	
NAOL10	Dormant	DORMANT
	Pre-Emergence	
UHPE10	Benefin	BENEFIN
UHPE20	Simazine	SIMAZINE
	Soil	
UHSL10	Fenac	FENAC
UHSL20	TBA	TBA
UHSL30	TCA	TCA
	Soil Sterilant	
UHSS10	Bromacil	BROMACIL
UHSS20	Diuron	DIURON
UHSS30	Fenuron	FENURON
UHSS40	Monuron	MOURON
UHSS50	Sodium Chlorate	SODIUMCHL
UHZZ00	Other Uncombined Herbicides	OUNCMHERB

The information provided in case situation 2-1 will be used in explaining the procedures used in determining the pounds of active ingredient contained in a finished product so that it can be properly recorded on the AF Form 290.

As stated in the case situation, 240 gallons of 6 percent malathion-oil solution was used for fogging, which is the finished product. This finished product was prepared from a 57-percent malathion E/C and a number 4 grade fuel oil. As you can see, there is no information contained here that can be entered on the AF Form 290; therefore, the information must be converted.

The first thing that must be done is to determine how much of the 57-percent E/C was required to prepare 240 gallons at 6 percent. By multiplying 6 × 240 and dividing it by 57 you will get an answer of 25.26 and you will have a quantity of 126 20. This quantity rounded off the the nearest whole number is 126, which is the information to be entered in the data

TABLE 2-4
PESTICIDE FORM DATA CODES

Data Codes	Data Items and Explanations:
	Pesticide Forms
	Dry
DUST	Dusts
GRAN	Granules
SFUM	Solid Fumigant
BAIT	Bait (Ready to Use)
OTHD	Other
	Liquid
SOLU	Solution
EMUL	Emulsion
AERO	Aerosol
SUSP	Suspensions
OTHL	Other

element identified as Pesticide Quantity as illustrated in figure 2-26.

NOTE: Only the columns required for the number of digits will be filled in from right to left, and only whole numbers will be entered in the columns under this data element.

The Unit of Measure data element for pesticide quantity must reflect "LB" in columns 37 and 38, respectively, to identify the fact that the information entered in the previous data element was recorded as pounds.

The Supply Source data element (column 39) must reflect either an "N" if the pesticide used was a non-standard stock item or an "S" if the pesticide was a standard stock item as illustrated in figure 2-26.

The Man-Hours Labor data element (columns 40 through 45) is used for the purpose of reflecting only the combined man-hours actually expended while applying pesticides to include supervisory time, as is illustrated by the figure appearing in columns 44 and 45 of figure 2-26.

As you can see, a total of 14 hours was entered under this data element to correspond with the information provided in case situation 2-1.

NOTE: Only whole numbers will be entered under this data element, which means that no part of an hour can be shown.

The purpose for the next data element identified as Man-Hours Survey is for recording only the hours spent in conducting surveys for a specific job. Looking at figure 2-26, you will notice that no entry appears under this data element although case situation 2-1 states that 3 hours were expended on surveys. The reason for this space being blank is that information pertaining to man-hours expended on surveys have to be keypunched onto a separate Pest detail card, which would be the Pest detail card 2/80, as previously stated. Therefore, this information cannot appear on the same line that is used for recording pest control operations to be keypunched onto the Pest detail card 1/80. To explain this further, figure 2-27 has been provided to illustrate how the survey hours for a pest control operation are recorded on a typical AF Form 290 that is prepared daily.

Notice that the illustrated AF Form 290 in figure 2-27 has the lines numbered in the left margin. This is to allow quick reference to the comments that remain concerning the completion of this form.

In comparing figure 2-26 with figure 2-27 you will find that line 1 in figure 2-27 provides the same information that figure 2-26 does. This information pertains strictly to pest control operations and is keypunched only on the Pest detail card 1/80. Line 7 in figure 2-27 represents the information keypunched onto the Pest detail card 2/80 (Pest Survey), and line 14 represents the information pertaining to herbicide control operations that are keypunched onto the Pest detail card 3/80.

Continuing the discussion concerning data element Man-Hours Survey, the 3 hours expended on surveys for the pest control operation described (in case situation 2-1) has been entered in column 51 on line 7 as illustrated in figure 2-27; which explains why it was not entered in the same column on line 1. If you will notice, entries have been made to only two data elements on line 7 prior to this one, because this is the only information that can be entered on the Pest Survey Card (2/80) up to this point.

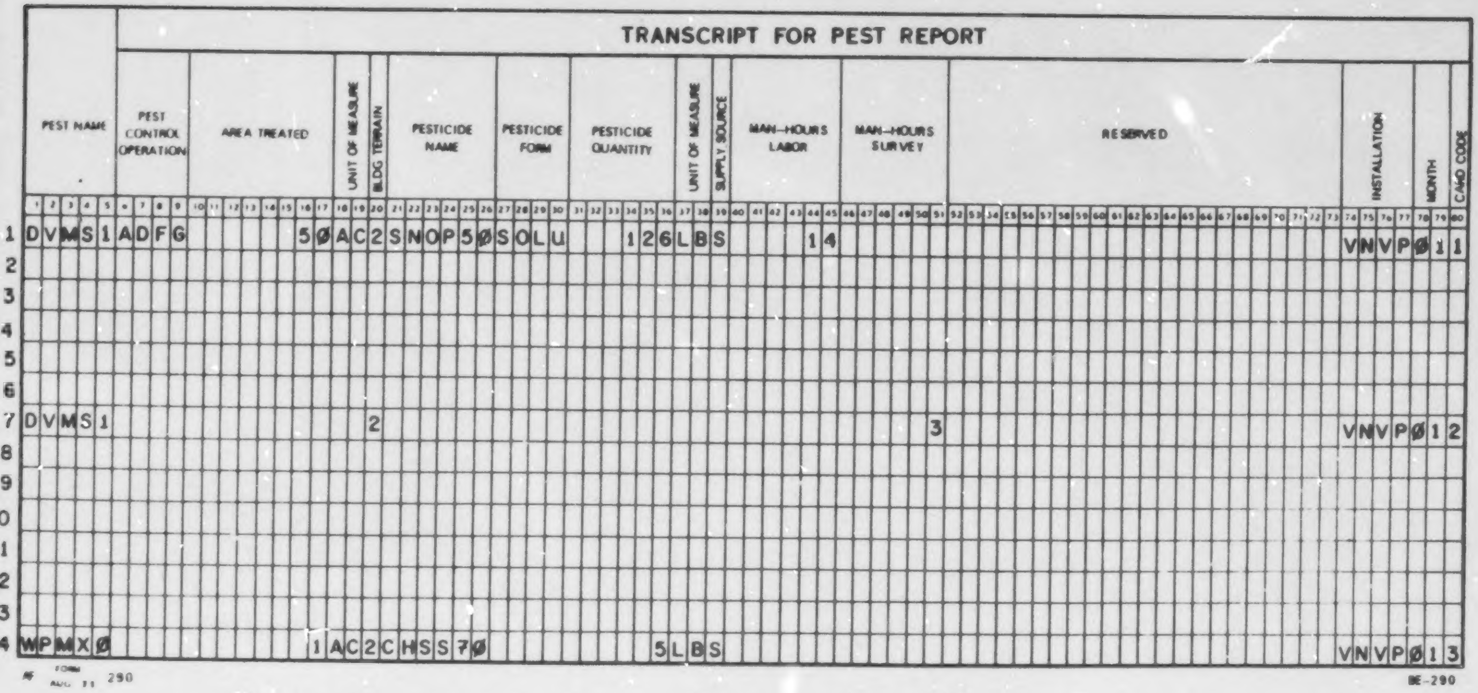
Continuing with the remaining data elements on the AF Form 290, the Reserved data element (columns 52 through 73) requires no entry. This space is to remain blank.

The Installation data element is used to identify the installation submitting the report. This code must be entered in columns 74 through 77 for each Pest detail card as has been done in figure 2-27. It is recommended that you obtain the proper data element code from the civil Engineering Cost Accounting Section; therefore, these codes are not provided in this text.

The Month data element is used to identify the month in which the form was prepared. This data element code must be a two-digit number. If the month happens to be December, then the number 12 would be entered in columns 78 and 79. Case situation 2-1 states that this job was accomplished in January; therefore, figures 2-26 and 2-27 reflect a 01, which is the proper way to enter the number that represents the month of January.

The last data element that remains on the AF Form 290 is *Card Code*. Column 80 is used for identifying the information entered on individual lines to the applicable Pest detail card. Notice that a "1" has been entered in column 80 on line 1 in figures 2-26 and 2-27 to identify that all the information on that line is to be keypunched onto a Pest Control Operation Card (1/80). In figure 2-27 you will note that a "2" was entered on line 7 to indicate that this information must be keypunched onto a Pest Survey Card (2/80) and a "3" entered on line 14, which means that all the information on this line must be keypunched onto a Herbicide Control Card (3/80).

Look on line 14 in figure 2-27 and observe the entries for the various data elements. This is an example of the complete information that is entered on the AF Form 290 for herbicide control. All blank data elements appearing on this illustrated form must remain blank because the computer will not accept any



TRANSCRIPT FOR PEST REPORT

	PEST NAME (1-5)	PEST CONTROL OPERATION (6-9)	AREA TREATED (10-17)	UNIT OF MEASURE (18-19)	BLDG TERRAIN (20)	PESTICIDE NAME (21-26)	PESTICIDE FORM (27-30)	PESTICIDE QUANTITY (31-36)	UNIT OF MEASURE (37-38)	SUPPLY SOURCE (39)	MAN-HOURS LABOR (40-45)	MAN-HOURS SURVEY (46-51)	RESERVED (52-73)	INSTALLATION (74-77)	MONTH (78-79)	CARD CODE (80)
1	DVMS1	ADFG	50	AC	2	SNOP50	SOLU	126	LB	S	14			VNVP	01	1
2																
3																
4																
5																
6																
7	DVMS1				2							3		VNVP	01	2
8																
9																
0																
1																
2																
3																
4	WPMX0		1	AC	2	CHSS70		5	LB	S				VNVP	01	3

AF FORM AUG 71 290

BE-290

Figure 2-27. AF Form 290, Transcript for Pest Report (example of pest control operation, pest survey, and herbicide control entries).

additional information and cannot be keypunched onto the Herbicide Control Card (3/80).

NOTE: For herbicide control operations on "A" and a "C" must be entered in columns 18 and 19, respectively, for the data element Unit of Measure and a "2" must be entered in column 20 for the data element Building Terrain for all herbicide control operations just as it appears on line 14 in figure 2-27.

Disposition. Once the AF Form 290 is completed it is forwarded to the Cost Accounting Section, and the information is keypunched onto the Pest detail cards. The AF Form 290s can be destroyed after a corrected copy of the Pest Summary Report has been prepared.

Exercises (231):

1. The AF Form 290 must be prepared ____________ in accordance with ______________ .

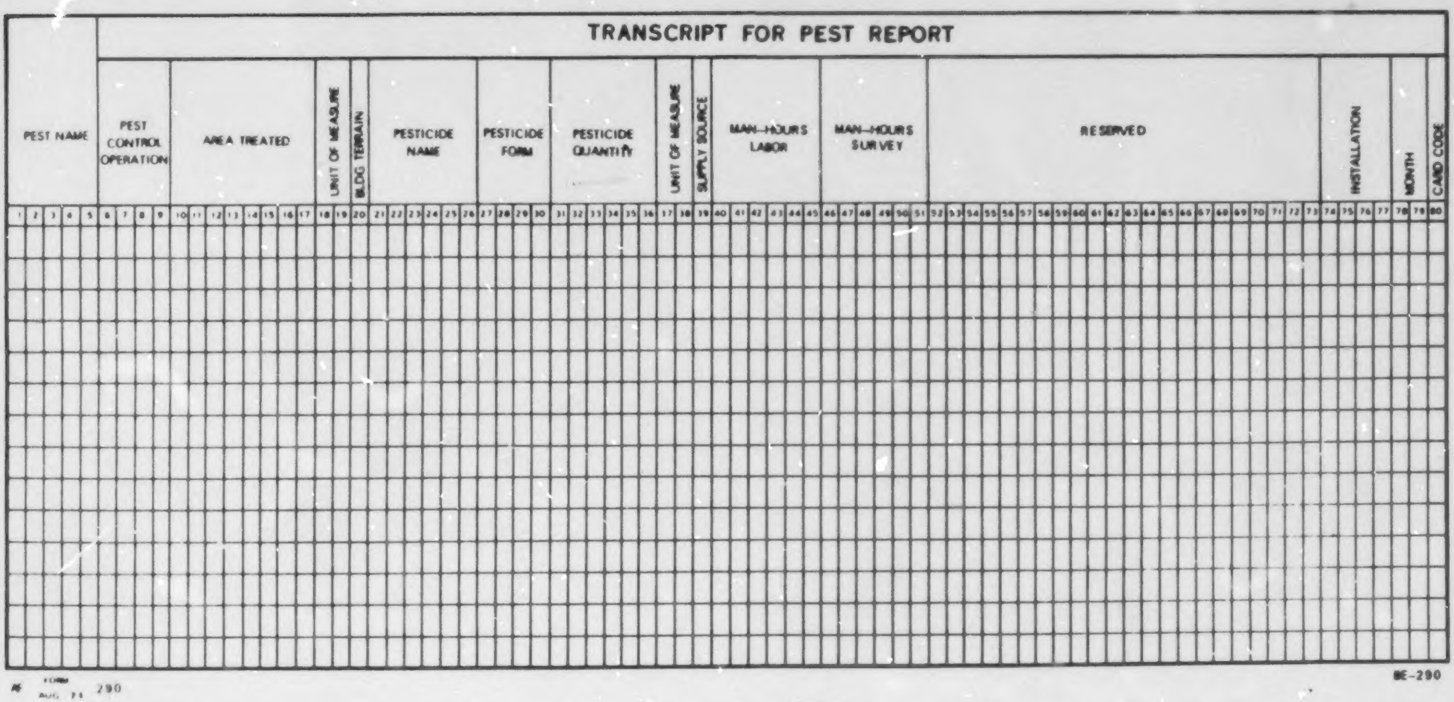
2. What is the primary purpose of the AF Form 290?

3. What does the information that is recorded on the AF form 290 pertain to?

4. The three publications that provide instructions for completing an AF Form 290 for use with the B3500 computer system are ____________, ____________, and ________________________ .

5. Data codes used in the completion of the AF Form 290 are found in ____________________ .

6. Using information in the objective pertaining to completion instructions for the AF Form 290, complete the blank AF Form 290 in figure 2-28 by entering the information below on the appropriate lines as illustrated in figure 2-26.



TRANSCRIPT FOR PEST REPORT

	PEST NAME	PEST CONTROL OPERATION	AREA TREATED	UNIT OF MEASURE	BLDG TERRAIN	PESTICIDE NAME	PESTICIDE FORM	PESTICIDE QUANTITY	UNIT OF MEASURE	SUPPLY SOURCE	MAN-HOURS LABOR	MAN-HOURS SURVEY	RESERVED	INSTALLATION	MONTH	CARD CODE
	1 2 3 4 5	6 7 8 9	10 11 12 13 14 15 16 17	18 19	20	21 22 23 24 25 26	27 28 29 30	31 32 33 34 35 36	37 38	39	40 41 42 43 44 45	46 47 48 49 50 51	52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73	74 75 76 77	78 79	80
1																
7																
14																

AF FORM AUG 71 290

BE-290

Figure 2-28. AF Form 290, Transcript for Pest Report (objective 229, exercise 6).

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On 4 October 1976 the Base Parade Grounds, which is 1 acre, was treated for chinch bugs. Since chinch bugs are vegetative juice-sucking pests and 1 acre is being treated, 200 gallons of a 0.5-percent emulsion finished spray is recommended. The finished spray was prepared from a 47.5-percent diazinon emulsifiable concentrate, which contains 4 pounds of active ingredient per gallon and is a standard stock item.

To accomplish this pest control operation, 1 hour was expended in conducting a survey, and it took two people 4 hours to mix and apply the pesticide. The supervisor observed the entire operation to insure that the job was progressing smoothly and to observe the performance of the individuals.

NOTE: No entry is required for the installation data element in this exercise.

CHAPTER 3

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Safety, Protective Equipment, and First Aid

PESTICIDES ARE only as safe as you are, because pesticides do not create accidents; people do! Accidents involving pesticides can be eliminated just as all other accidents can, if everyone will become knowledgeable of accident prevention and adhere to all preventive measures without deviations.

This chapter will identify the requirements and guidelines for handling pesticides safely. And, since it is recognized that humans err, and pesticide poisonings do occur, this chapter will discuss the common causes of these poisonings and the actions to be taken when they occur.

3-1. Federal Statutes and Regulations

Without pesticides, we would not have the food, fiber, and landscape plants we need. But because pesticides can be dangerous, Congress has passed laws affecting pesticide use. These laws try to balance the need for pesticides against the need to protect people and the environment from their misuse.

The intent within this section is to identify the Federal agencies that establish and enforce laws governing all phases of pesticide handling.

232. State the purpose and scope of the FIFRA.

Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). This act was first established by Congress in 1947 and was administered by the United States Department of Agriculture (USDA), Agricultural Research Service, Pesticides Regulation Division.

Purpose. This act was established to provide laws pertaining to the certification of the usefulness of chemicals employed in agriculture, specified requirements for safety precautions in handling and applying agricultural chemicals, and specified requirements for the registration of such chemicals every 5 years.

Scope. There have been five amendments to this act since the basic act was established. The first amendment occurred in 1959 to include nematodes, plant growth regulators, desiccants, and defoliants; and then in 1963, it was amended again to require labels of economic poisons to provide the statement "Keep Out of Reach of Children" and to eliminate claims such as "Safe," "Nonpoisonous," "Nontoxic," "Noninjurious," and "Harmless" from economic poison labels.

Then, on 12 May 1964 there were two amendments to the FIFRA passed by Congress. The first of these was Public Law 201, which eliminated the protest registration clause of the basic act. The second amendment enacted on 12 May 1964 was Public Law 305, which established the requirement for each pesticide label to show a registration number when the pesticide has been approved by the USDA for registration.

Exercises (232):

1. State the three purposes identified in the text for establishing the FIFRA by listing them in the order given.

2. The amendment to the FIFRA that was enacted in 1963 required all economic poison labels to provide the statement "____________."

3. The regulations set forth in FIFRA are made into law by ____________.

4. The FIFRA was first amended to include __________, __________, __________, and __________.

233. Specify the relationship of the FIFRA and the FEPCA and identify the new requirements outlined in the FEPCA.

Federal Environmental Pesticide Control Act (FEPCA). The FEPCA was amendment number 5 to the FIFRA passed by Congress and became

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Public Law 92-516, which is most often referred to as "FIFRA, as amended."

Purpose. The FEPCA became law on 21 October 1972 to extend Federal registeration and regulation to all pesticides, including those distributed or used within a single state.

Scope. This FEPCA requires the proper application of pesticides to insure greater protection of humans and the environment. It prohibits the use of any registered pesticide in a manner inconsistent with labeling instructions and it also specifies that pesticides must be classified as either general or restricted.

Under the provisions of the FEPCA every commercial and private applicator must be certified as competent to use any of the pesticides that are classified as being restricted. FEPCA also provides penalties such as fines and jail terms for people who do not obey this law.

As an entomology specialist, you are governed by this act because you are classified as a commercial applicator of pesticides. As a result of this, you will be required to be certified to apply restricted use pesticides, and you are subject to the penalties prescribed if you do not adhere to the law.

To be certified, you must prove that you know the safe and correct way to apply restricted use pesticides. To do this, you take a written examination. Therefore, the more you study this CDC the more knowledgeable you will be when it comes test time.

The civil penalties that you are subject to if you violate the FIFRA may be a fine of up to $5,000 for each offense, and the criminal penalties may be as much as $25,000 or 1 year in prison, or both.

Exercises (233):

1. The relationship of the FEPCA to the FIFRA is that the FEPCA is actually an ____________ to the ____________ .

2. What is the purpose of the FEPCA?

3. Identify the requirements that were outlined in the FEPCA which had not been outlined previously in the FIFRA by placing an X in the space beside each statement that applies.

____ a. Requiring certification of the usefulness of chemicals employed in agriculture.
____ b. Requiring the inclusion of nematodes, palnt growth regulators, desiccants, and defoliants.
____ c. Included provisions for penalties in case of pesticide misuse.
____ d. Requiring the classification of pesticides as being restricted or general.
____ e. Requiring the statement "Keep Out of Reach of Children" be printed on the pesticide label.
____ f. Requiring each commercial and private applicator of pesticides to be certified competent.
____ g. Requiring the registration of each pesticide by the USDA.

234. State the purpose for creating the EPA and identify the scope of its functions.

Environmental Protection Agency (EPA). The EPA is the prime regulatory, research, and educational agency with the knowledge and capability to control all environmental pollutants. This agency includes organizations concerned with pesticides, or their effect on the environment, which were previously parts of the Council on Environmental Quality, the Atomic Energy Commission, and the Departments of Agriculture, Interior, and Health, Education, and Welfare.

Purpose. The EPA was created on 2 December 1970 by Congress as a result of the continuing pressure to limit the use of pesticides and to combine all activities of the Federal Government concerned with pesticides and their effects on the environment into a single agency.

Scope. This agency has the responsibility for researching, developing, and enforcing standards, prescribed by law, for emissions and effluents; evaluating and registering pesticides and developing new pest management procedures; controlling toxic and poisonous substances; developing new methods in pollution control; and insuring that adequate technical personnel requirements are developed.

As a result of combining all the organizations identified above into a single agency, the EPA now has the responsibility for enforcing the FIFRA, as amended (FEPCA). These responsibilities include, but are not limited to, registering each and every pesticide, classifying pesticides, prosecuting individuals for misuse of pesticides, and insuring that minimum standards for certification are established and complied with.

Exercises (234):

1. What was the purpose for creating the EPA?

2. Of the statements provided, identify the ones that pertain to the functions of the EPA by placing an X beside applicable statements.

____ a. Approves and registers all pesticides for their uses.
____ b. Enacts laws pertaining to pesticides.
____ c. Enforces the FEPCA.

____ d. Responsible for developing new pest management procedures.

____ e. Certifies all personnel as being competent to apply pesticides.

3. List the three departmental organizations that are included under the EPA.

235. Identify the governing department for the OSHA and its purpose, and state the scope of the OSHA pertaining to its functional responsibilities.

Occupational Safety and Health Administration (OSHA). The OSHA is an organization that operates under the US Department of Labor (USDL) with regional offices established throughout the United States.

Purpose. The purpose of the OSHA is to insure that all employees have safe and healthy working conditions. As you will see in Section 3-2 of this chapter, there are many requirements established by the OSHA to insure safe entomological operations.

Scope. The OSHA has authority to develop and publish occupational safety standards; inspect work areas to insure that standards are met; issue citations for noncompliance with its regulations; and maintain education, training, and information programs to promote safe practices.

This administration is a very valuable source to obtain assistance in establishing safe working conditions for you and your fellow workers.

Exercises (235):

1. What is the governing department for the OSHA?

2. State the purpose for the OSHA.

3. List the functional responsibilities of the OSHA.

236. Identify the governing department for the NIOSH and its purpose, and list the functions and responsibilities within its scope.

National Institute for Occupational Safety and Health (NIOSH). The NIOSH is an organization that operates under the US Department of Health, Education, and Welfare (USDHEW).

Purpose. The NIOSH prepares new or improved occupational safety and health standards and provides qualified personnel to enforce these standards.

Scope. This organization under the USOHEW is responsible for formulating new or improved occupational safety and health standards and for conducting educational programs to provide an adequate supply of qualified personnel to carry out these standards.

The NIOSH now has the responsibility for testing and approving many items of personal safety protective equipment required in entomological operations that formerly was the responsibility of the US Bureau of Mines. This will be brought to your attention in Section 3-2 of this chapter when respiratory protective devices are discussed.

Exercises (236):

1. The NIOSH is an activity that is controlled by what department?

2. The NIOSH was formed to (enforce occupational and health standards) or to (formulate improved occupational and health standards). Underline the correct purpose.

3. Name a responsibility of the NIOSH identified in the text that is directed toward you as an entomology specialist.

237. Point out how the statutes and regulations of the EPA and the OSHA relate to State and local control over Air Force pest management programs.

State and Local Statutes and Regulations. Although the EPA establishes the minimum Federal requirements for environmental protection and the OSHA establishes the minimum Federal requirements for safe working conditions, the State and local governments have the perogative of establishing more stringent requirements for environmental protection and safe working conditions.

As an Air Force pest manager you must be very knowledgeable of the laws established within the State and community to which you are assigned. You must perform all entomological functions within the laws established by the State and local government, if their laws are more stringent than Federal laws.

Exercises (237):

1. When can the State and local governments override Federal statutes and regulations established by the EPA and the OSHA in regard to protecting the environment and employees?

2. Based upon the information contained in this objective, you an an Air Force pest manager must adhere to which requirements?

3. What is the primary function of EPA?

3-2. Safe Handling of Pesticides

As an entomology specialist, it is your responsibility to take every precaution available during all phases of pesticide handling to protect yourself, fellow workers, and others and to prevent accidental destruction of property through negligence.

Since all pesticides are toxic to some form of life and many are explosive and flammable, they present many hazards to the environment in one way or another or a combination of ways. These hazards can be reduced to almost nonexistent if you and everyone else will follow the basic precautionary rules for handling pesticides.

This section will identify and explain pesticide labels and will identify the facility requirements for entomology sections and the safety requirements to be adhered to during all phases of pesticide handling.

238. State the purpose and uses of pesticide labels, identify the parts of a pesticide label, and interpret signal words and symbols that may appear on pesticide labels.

Pesticide Labels. Each and every pesticide is required to be registered by EPA, and each pesticide container is required to be labeled.

EPA has established strict regulations requiring a minimum of information to be furnished by the manufacturer and printed on each pesticide container label before it can be registered.

You have probably already noticed the frequency in which the pesticide label has been referred to in the previous portions of this text, and it will be referred to over and over again in the remaining portions because the pesticide label is the most important and informative source for identifying the pesticide and the safe handling precautions.

Purpose of pesticide labels. The pesticide label serves the same purpose as an Air Force regulation and must be strictly adhered to. Any deviation that would be to a less degree than the information provided by the pesticide label subjects you to the same punishments as the disobeyance of an Air Force regulation would. In addition to this, you will be subject to a fine, imprisonment, or both under Federal laws governing the use of pesticides. However, you are encouraged to take more precautionary measures than stated on the pesticide label. In fact, more such precationary measures are sometimes required by other regulations.

Remember that EPA has only established minimum standards to be followed when handling pesticides, and other agencies can establish and enforce stricter standards.

Use of pesticide labels. The pesticide label is used as a guideline for the safe storage, mixing, uses, and application of that specific pesticide. These guidelines for safe storage, mixing, and application must be recognized as the very minimum standard that must be met, but the standard can be increased. The specific recommendations for the uses and actual mixing and application rates that are provided on the pesticide label must not be deviated from under any circumstance. All other recommendations pertaining to pesticide use, formulation, and application, such as the pesticide recommendations that are included in Appendix A of supplements to Volumes 4, 5, 6, and 7 of this CDC, in AFM 91-16, and in AFM 91-19, must be recognized as being only general recommendations that may be obsolete and will no longer apply.

When you find contradictory information between the recommendation provided on the pesticide label and pesticide recommendations provided in the CDC, AFM 91-16, and AFM 91-19, always follow the recommendations on the label.

Remember that pesticide manufacturers expend much time, effort, and money in conducting research on their products and they are the authoritative source!

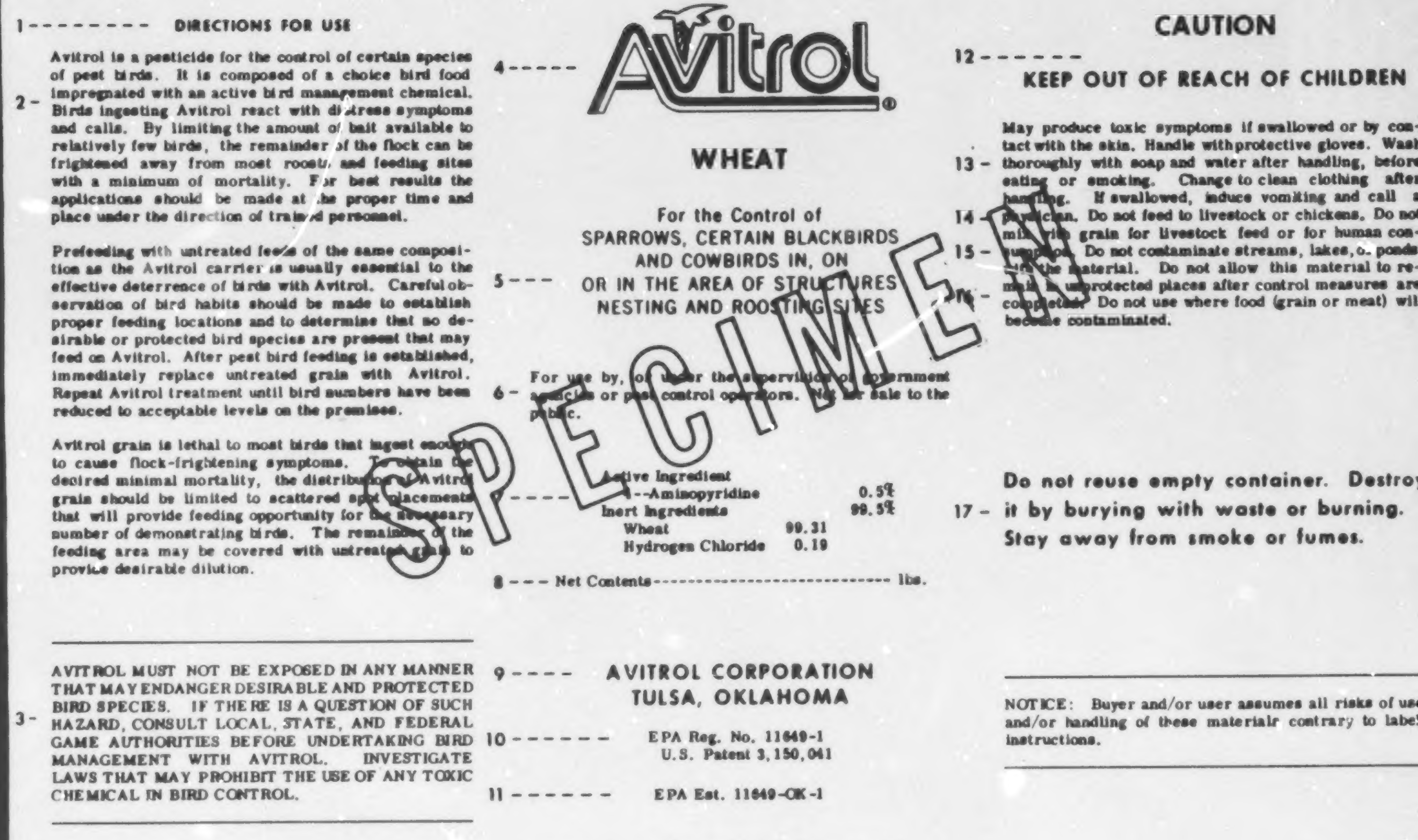
Parts of the label. As previously stated, EPA requires that certain information concerning each pesticide be provided on each and every pesticide container label.

To assist you in recognizing and identifying the type of information that is provided on a typical pesticide container label, a specimen label and explanations concerning the parts of a typical pesticide label are provided below.

Figure 3-1 is provided for your reference throughout the discussion concerning the parts of a typical pesticide container label.

a. Brand name. Each company has brand names for its products and is the most identifiable name. This name is the one that appears in ads and is identified vividly on each pesticide label as is shown beside the number "4" in figure 3-1.

b. Common name. Many pesticides have complex chemical names. Some have been given another name to make them easier to identify. These are called *common names.* For instance, carbaryl is the *common name* for 1-naphthyl N-methylcarbamate. A chemical



1 -------- **DIRECTIONS FOR USE**

2 - Avitrol is a pesticide for the control of certain species of pest birds. It is composed of a choice bird food impregnated with an active bird management chemical. Birds ingesting Avitrol react with distress symptoms and calls. By limiting the amount of bait available to relatively few birds, the remainder of the flock can be frightened away from most roosts and feeding sites with a minimum of mortality. For best results the applications should be made at the proper time and place under the direction of trained personnel.

Prefeeding with untreated feeds of the same composition as the Avitrol carrier is usually essential to the effective deterrence of birds with Avitrol. Careful observation of bird habits should be made to establish proper feeding locations and to determine that no desirable or protected bird species are present that may feed on Avitrol. After pest bird feeding is established, immediately replace untreated grain with Avitrol. Repeat Avitrol treatment until bird numbers have been reduced to acceptable levels on the premises.

Avitrol grain is lethal to most birds that ingest enough to cause flock-frightening symptoms. To obtain the desired minimal mortality, the distribution of Avitrol grain should be limited to scattered spot placements that will provide feeding opportunity for the necessary number of demonstrating birds. The remainder of the feeding area may be covered with untreated grain to provide desirable dilution.

3 - AVITROL MUST NOT BE EXPOSED IN ANY MANNER THAT MAY ENDANGER DESIRABLE AND PROTECTED BIRD SPECIES. IF THERE IS A QUESTION OF SUCH HAZARD, CONSULT LOCAL, STATE, AND FEDERAL GAME AUTHORITIES BEFORE UNDERTAKING BIRD MANAGEMENT WITH AVITROL. INVESTIGATE LAWS THAT MAY PROHIBIT THE USE OF ANY TOXIC CHEMICAL IN BIRD CONTROL.

4 ----- Avitrol®

WHEAT

5 --- For the Control of
SPARROWS, CERTAIN BLACKBIRDS
AND COWBIRDS IN, ON
OR IN THE AREA OF STRUCTURES
NESTING AND ROOSTING SITES

6 - For use by, or under the supervision of government agencies or pest control operators. Not for sale to the public.

7 ---- Active Ingredient
4--Aminopyridine 0.5%
Inert Ingredients 99.5%
Wheat 99.31
Hydrogen Chloride 0.19

8 --- Net Contents ---------------------------- lbs.

9 ---- **AVITROL CORPORATION**
TULSA, OKLAHOMA

10 ------ EPA Reg. No. 11649-1
U.S. Patent 3,150,041

11 ------ EPA Est. 11649-OK-1

CAUTION

12 ------ **KEEP OUT OF REACH OF CHILDREN**

13 - 14 - 15 - 16 - May produce toxic symptoms if swallowed or by contact with the skin. Handle with protective gloves. Wash thoroughly with soap and water after handling, before eating or smoking. Change to clean clothing after handling. If swallowed, induce vomiting and call a physician. Do not feed to livestock or chickens. Do not mix with grain for livestock feed or for human consumption. Do not contaminate streams, lakes, or ponds with the material. Do not allow this material to remain in unprotected places after control measures are completed. Do not use where food (grain or meat) will become contaminated.

17 - **Do not reuse empty container. Destroy it by burying with waste or burning. Stay away from smoke or fumes.**

NOTICE: Buyer and/or user assumes all risks of use and/or handling of these materials contrary to label instructions.

Figure 3-1. Typical pesticide container label.

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made by more than one company will be sold under several brand names, but you may find the same common name or chemical name on all of them. There is no common name for the pesticide on the illustrated pesticide label, but the chemical name is identified directly beneath the active ingredient beside the number "7."

c. Ingredient statement. Every pesticide label must list what is in the product. The list is written so that you can see quickly what the active ingredients are. The amount of each *active ingredient* is given as a percentage by weight or as pounds per gallon of concentrate. It can be listed by either the chemical name or the common name. The *inert ingredients* need not be named, but the label must show what percent of the contents they make up. This statement is identified beside the number "7" in figure 3-1.

d. Net contents. The net contents number tells you how much product is in the container. This quantity may be expressed in gallons, pints, pounds, quarts, or other units of measure. The net contents line is identified beside the number "8" in figure 3-1. If the label was actual, there would be a quantity entered on the line.

e. Name and address of manufacturer. The law requires the producer or distributor of a product to put the name and address of the company on the label. This is so you will know who made or sold the product. This information is beside the number "9" in figure 3-1.

f. Registration and establishment number. A registration number must be on every pesticide label. It shows that the product has been registered with the Federal Government. It usually is found on the front panel of the label and will be written as "EPA Registration No. 0000." The establishment number tells what factory made the chemical. This number does not have to be on the label, but will be somewhere on each container. The EPA registration and establishment numbers are identified beside the numbers "10" and "11," respectively, in figure 3-1.

g. Directions for use. The instructions on how to use the pesticides are an important part of the label for you. This is the best way you can find out the right way to apply the product.

The use instructions will tell you:

- The pests the product is registered to control. (Labels use common names for pests. Knowing these names will help you choose the proper pesticide and find control information.)
- The crop, animal, or other item the product can be used on.
- Whether the product is for general or restricted use.
- In what form the product should be applied.
- How much to use.
- Where the material should be applied.
- When the material should be applied.

This information is identified beside the numbers "1" and "5" in figure 3-1.

The *misuse statement* is to remind you that it is a violation of Federal law to use a product in a manner inconsistent with its labeling. Do not use a product on a crop or for a pest not listed on the label. Do not use it at more than the recommended rate. Before the product could be registered, EPA required to manufacturer to conduct many tests to be sure the label directions were correct. By following them exactly, you will:

- Get the best results the product can give.
- Avoid breaking the law.

This information is identified beside the number "3" in figure 3-1.

A *reentry statement,* if required for the product, will tell you how much time must pass before an area treated with the pesticide is safe for reentry by a person without protective clothing. Consult an authoriative source for special rules that may apply.

The specimen label shown in figure 3-1 does not have a reentry statement because it is not applicable.

The *category of applicator,* if required for the product, will limit use to certain categories of commercial applicators.

Although this information is not readily identifiable, it is included beside the number "6" in figure 3-1.

Storage and disposal directions must be provided on each pesticide container label to tell you how to store and dispose of the product and empty containers.

This information is identified on the specimen label beside the number "17" in figure 3-1.

h. Signal words and symbols. In order to do their job, most pesticides must control the target pest. By their nature, they are toxic. Therefore, some may be hazardous to people. You can tell the toxicity of a product by reading the *signal word* and looking at the *symbol* on the label.

The *signal word* is one of the most important parts of the label. It tells you approximately how toxic the pesticide is to humans. The signal words as provided in figure 3-2 are established by law, and each manufacturer is required to use the current one on each and every label. In addition to the signal word, the statement "Keep Out of Reach of Children" must be included on each and every label.

The signal word along with the statement is identified beside the number "12" in figure 3-1.

Now, refer to figure 3-2 and you can see that the signal word CAUTION that is contained on the specimen label means that this product has a low toxicity or is comparatively free from danger to humans.

The *symbol* is one of the best ways to catch a person's eye, and this is why a skull and crossbones symbol is used on all highly toxic pesticides along with the signal word DANGER and the word POISON.

Signal Words	Toxicity	Approximate Amount Needed To Kill the Average Person
DANGER	Highly toxic	a taste to a teaspoonful
WARNING	Moderately toxic	a teaspoonful to a tablespoonful
CAUTION	Low toxicity or comparatively free from danger	an ounce to more than a pint
All products must bear the statement "Keep out of reach of children."		

Figure 3-2. Signal words.

The specimen label provided in figure 3-1 does not have a skull and crossbones because the product is not highly toxic.

i. Type of formulation. Different types of pesticide formulations (such as liquids, wettable powders, and dusts) require different methods of handling. The label will tell you what type of formulation the package contains. The same pesticide may be available in more than one formulation. Although this information is not readily identifiable on the specimen label provided, it can be seen beside the number "2" in figure 3-1.

j. Precautionary statement. The precautionary statement will provide you with information concerning the hazards to humans and domestic animals, environmental hazards, and physical and chemical hazards. This information will be included on the pesticide label if applicable to the product.

The *hazards to humans and domestic animals* statement will tell you the ways in which the product may be poisonous to man and animals. It also will tell you of any special steps you should take to avoid poisoning, such as the kind of protective equipment needed.

If the product is highly toxic, this section will inform physicians of the proper treatment for poisoning.

This type of information is identified beside the number "13" in figure 3-1.

The *environmental hazards* statement is included on pesticide labels to assist you in avoiding wrong or careless use of the product to prevent environmental damage.

Examples of this type of information are as follows:

- "This product is highly toxic to bees exposed to direct treatment or to residues on crops."
- "Do not contaminate water when cleaning equipment or when disposing of wastes."
- Do not apply where runoff is likely to occur."

Labels may contain broader warnings against harming birds, fish, and wildlife.

This information is identified beside the number "15" on the specimen label in figure 3-1.

The *physical and chemical hazards* statement will warn you of any special fire, explosion, or chemical hazards that may be presented by the product.

This information has not been included on the specimen label.

k. Statement of practical treatment. If swallowing or inhaling the product or getting it in your eyes or on your skin would be harmful, the label will tell you emergency first aid measures. It also will tell you what types of exposure require medical attention.

The pesticide label is the most important information you can take to the physician when you think someone has been poisoned.

The statement of practical treatment is identified beside the number "14" in figure 3-1.

l. Statement of use classification. Once EPA has finished the process of classifying all pesticides as being in either the general use or restricted use category, all manufacturers of pesticides will be required by law to identify each of their products by providing this information on each of their product labels.

EPA is classifying pesticides into the categories on the basis of:

- The hazard of poisoning.
- The way the pesticide is used.
- Its effect on the environment.

The *general use* category is for pesticides that present very little or no hazard to the applicator or the environment when used exactly as identified by the information on the label.

The label on the general use pesticides will read "General Classification."

The *restricted use* category is for pesticides that could cause some human injury or environmental damage even when used as directed on the label. The label on these products will say:

"Restricted use pesticide for retail sale to and application only by certified applicators or persons under their direct supervision."

The restricted use statement must be at the top of the front panel of the label.

The specimen label that is illustrated in figure 3-1 does not contain the information pertaining to its category of use because it has not been developed.

As you have seen, the pesticide label contains much information, although some of it is not readily depicted. You must train yourself to always read the pesticide container label and follow all instructions provided on this document to protect all environmental elements as much as possible.

Exercises (238):

1. What is the purpose of pesticide labels?

2. The pesticide label is used as a guideline for ______________.

3. A skull and crossbones is used on ______________.

4. Match column A with column B.

Column A

______ a. EPA Reg. No. 11649-1.
______ b. 99.5% inert.
______ c. If swallowed induce vomiting and call a physician.
______ d. DANGER.
______ e. Avitrol.
______ f. Restricted use pesticide for retail sale to and application only by certified applicators.
______ g. Avitrol, Tulsa, Oklahoma.
______ h. Handle with protective gloves.
______ i. Carbaryl.
______ j. Pellet form.
______ k. 3 pounds.
______ l. When it should be applied.

Column B

1. Brand name
2. Common name
3. Ingredient statement
4. Net content
5. Name, address of manufacturer
6. Registration and establishment number
7. Directions for use
8. Signals words and symbols
9. Precautionary statement
10. Type of formulation
11. Statement of practical treatment
12. Statement of use classification

239. Specify the location in which an entomology facility should be located and identify the functional areas that should be contained within an entomology facility.

Facility Requirements for Entomology Sections. Having the proper entomology facility is just as important to the safety mission as wearing protective equipment and should be enforced just as emphatically; however, like trying to justify preventive pest management programs as opposed to corrective pest management programs to higher levels of management, it is your responsibility to submit sufficient justification to obtain an adequate entomology facility.

There are several publications available that will identify the location, construction design, and furnishing that is required for an entomology section which may assist you in preparing the justification, if needed.

If there is only one inadequate entomology facility within the Air Force, this constitutes far too many inadequate facilities for safe storage of pesticides and pesticide dispersal equipment, mixing of pesticides, and personnel hygiene and protection.

The purpose of this objective is to identify the location and type of facility that should be utilized for an entomology shop and to identify the basis for justification.

Facility location. Entomology shops and other facilities that are utilized for storage of pesticides and pesticide dispersal equipment must be located in an area separate from other activities to prevent contamination to the environment and to personnel during normal operations or in case of fire or pesticide spills. Entomology shops or any other area that is utilized for storing entomological equipment and supplies must not be utilized jointly with any other activity or function due to the unique hazards presented by pesticides of various types.

These requirements are outlined in EPA Standard 40 CFR 165.10 (b).

Facility layout. An entomology shop must contain adequate space and specific functional areas to comply with safety and medical directives.

A facility that is utilized as the focal point for entomological functions must contain the following areas as a minimum:

- Insecticide storage area.
- Herbicide storage area.
- Pesticide dispersal equipment storage area.
- Pesticide dispersal equipment wash area.
- Pesticide mixing area.
- Personal hygiene area.
- Office area.

Facility design. In order for an entomology shop to be adequate for performing entomological functions safely, the functional areas within the facility must be designed to meet, at least, the minimum safety requirements that are outlined in EPA and OSHA Standards, NEC (National Electrical Code) Articles, and Air Force publications.

a. General facility design. Entomology facilities must be designed to provide sufficient space to permit the proper storage of all pesticides and pesticide dispersal equipment, the installation of required safety items within the mixing and formmulating area, required items for personal hygiene to be installed, the installation of required office equipment, and the installation of a wash area for equipment.

In addition to sufficient space, the following requirements exist:

(1) The ceiling height of this facility must be a minimum of 7½ feet. OSHA Standard 29 CFR 1910.37(i).

(2) There must not be any projections extending from the ceiling that are less than 6 2/3 feet. OSHA Standard 29 CFR 1910.37(i).

(3) Floors must be constructed of concrete or impervious material to facilitate easy cleanup of pesticide spills and must be of nonslip design. EPA Standard 40 CFR 165.10(c) (4).

(4) There must be at least two unobstructed exits for each confined space. OSHA Standard 29 CFR 1910.36(b) (8).

(5) All exits must be at least 2½ feet wide. OSHA Standard 29 CFR 1910.37(f) (6).

(6) All doors within the facility must open outward (when exiting from the area being sealed off). AFR 127-101, Chap 6, paragraph 4-1.a.(5).

(7) Fire exits must be equipped with panic hardware. AFR 127-101, Chap 6, para 4-1.a.(5).

(8) Fire exits must be identified with illuminated signs that are in red letters on a white background or vice versa. AFR 127-101, Chap 4, para 4-1.a.(10) (a).

(9) The facility must be provided with the proper quantity and quality of illumination for each functional area. (The proper quantity of light is regulated or determined by the minimum standards established in AFM 88-15 and AFR 127-101, Chap 5, para 5-4.b.(1).).

(10) Electrical outlets and switches must be properly grounded and wired for polarity. NEC Article 210-7.

(11) There must be a specially designed area that is paved or lined with impervious material with a closed drainage system for equipment washing. EPA Standard 40 CFR 165.10(c) (4).

(12) Hot and cold potable water must be readily available within the facility. OSHA Standard 29 CFR 1910.141(b).

It is recognized that this list is not a complete listing of all the general designs for an entomology facility; however, it does provide you with the basics. Others will be identified as the discussion continues with the design requirements for each functional area.

b. Pesticide storage areas. Entomology facilities must be designed to provide safe storage of pesticides. The pesticide storage facility requirements are as follows:

(1) All facilities utilized for storing pesticides must be enclosed with a climb-proof fence to exclude unauthorized personnel. EPA Standard 40 CFR 165.10(c)(1).

(2) Pesticides must be separated into like substances and stored in separate areas because unlike substances may possibly react with each other, which could present potential explosion and fire hazards. AFM 127-101, Chap 6, para 6-8e.

(3) Pesticide storage areas must be constructed to contain water and other materials used in firefighting. EPA Standard 40 CFR 165.10(g)(2).

(4) Electrical outlets, switches, and lighting must be explosion-proof. AFR 127-101, Chap 6, para 6-8e.

(5) Adequate ventilation (a complete change of air within the room at least six times per hour) must be provided. OSHA Standard 29 CFR 1910.106(d)(4) and AFR 127-101, Chap 6, para 6-8j.

(6) Doors and windows must contain locks that are designed to prevent the possibility of entrapment within the storage area. AFR 91-21, para 5a.

(7) Pesticide storage areas should be insulated to prevent freezing and overheating and must be fire-resistant. AFR 127-101, Chap 12, para 12-28a.

(8) Sufficient illumination must be provided as prescribed by AFM 88-15, AFR 127-101, Chap 5, para 5-4 b(1).

c. Equipment storage and maintenance area. The entomology facility must be designed for storing pesticide dispersal equipment to provide security and to facilitate preinspections, maintenance, and filling.

The equipment storage area should be large enough to store all hand- and power-operated dispersal equipment and should be provided with a large workbench.

Since entomology personnel are required to perform all maintenance within their capability (minor or major) on all types of pesticide dispersal equipment and most equipment reconditioning occurs during the coldest time of the year, the facility should be designed with an exhaust ventilation system to remove carbon monoxide while equipment is being checked and tuned.

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d. Pesticide mixing area. The following facility requirements exist for the pesticide mixing area:

(1) A deep stainless steel sink for mixing.
(2) Hot and cold water.
(3) Eyewash, AFR 127-101, Chap 3, para 3-31d.
(4) Deluge shower, AFR 127-101, Chap 3, para 3-31d.
(5) Exhaust ventilation with hood over the mixing sink, AFR 127-101, Chap 3, para 3-31e.
(6) A rack for drying and storing small pesticide sprayers, and measuring and mixing equipment.
(7) Sufficient illumination, which is of utmost importance, AFR 127-101, Chap 5, para 5-4 b(1).

e. Personal hygiene area. An entomology facility must be equipped with a suitable personal hygiene area to encourage and facilitate personal cleanliness.

The following requirements exist for the personal hygiene area in accordance with AFR 127-101, Chap 5, para 5-10 a (1):

(1) Shower.
(2) Lavatory.
(3) Commode.
(4) Personal lockers.
(5) Towel dispensers.
(6) Washing machine.
(7) Dryer.

f. Office area. An office area must be provided for entomological functions and should be furnished with the following equipment:

(1) Office desk.
(2) Filing cabinet.
(3) Chairs.

The office should be sealed to prevent toxic pesticide vapors and be properly ventilated and illuminated.

If you know for a fact or even suspect that the entomology shop to which you are assigned is not adequate or does not comply with the standards established by EPA and OSHA with regard to its location or layout, you should bring this to the attention of your supervisor.

In order to have your suspicions confirmed or have the discrepancies corrected, you must first expend all efforts through the chain of command established for you; and secondly, if no action has been taken by anyone within your chain of command, you may have to bring these discrepancies to the attention of the Ground Safety Office of Medical Services. Remember, it is your responsibility to do everything within your ability to protect the environment, yourself, and everyone else from the hazards associated with pesticides.

NOTE: Technical guidance and assistance is available through EPA and OSHA Regional Offices to answer any questions you may have with regard to the environment and industrial safety.

Exercises (239):

1. Where should the entomology facility be located with respect to other activities?

2. What type floor should be in the entomology shop area?

3. What is the minimum ceiling height of the entomology shop area?

4. Place an X in front of those functional areas which are located in the entomology facility.

____ a. Recreational area
____ b. Insecticide storage area
____ c. Chemical laboratory
____ d. Herbicide storage area
____ e. Dining area
____ f. Pesticide dispersal equipment storage area
____ g. Chemical storage area
____ h. Paint storage area
____ i. Pesticide dispersal equipment wash area
____ j. Pesticide mixing area
____ k. Spray booths
____ l. Personal hygiene area
____ m. Office area

5. Where can you find the minimum safety requirements for an entomology facility?

6. Why must pesticides be separated into like substances and stored in separate areas?

7. To reduce the possibility of breaking toxic vapors while mixing pesticides indoors, what should the mixing area contain?

8. Adequate ventilation within a pesticide storage room is described as being when there is a complete change of air within the room at least ______ times per hour.

9. In what area of an entomology facility should the diluge shower be installed?

240. Specify selected pesticide storage precautions and requirements.

Storage Precautions. To reduce or prevent explosion and fire hazards and to protect yourself and others from pesticide poisoning while pesticides and equipment are being stored, the following precautions must be taken:

(1) Pesticides must be stored in accordance with label recommendations.

(2) All pesticide and pesticide dispersal equipment storage areas must be kept locked when not in use.

(3) Pesticides must be stored out of reach of children.

(4) Exhaust ventilation must be turned on prior to entering storage areas.

(5) The "No Smoking, eating, or drinking rule" must be observed while in storage areas.

(6) Unlike pesticide substances must be stored separately.

(7) Excess, illegal, and expired shelf-life pesticides must be segregated and stored separately according to the method of disposal.

(8) Each storage area must be properly identified as to the type of substance contained and labeled on the outer surface of the door.

(9) Warning signs that read "Warning—Pesticide Storage" or other similar signs must be posted on each visible side of the storage area.

(10) A list of chemicals contained within the storage area must be posted on the outer surface of each door.

(11) Names, addresses, and phone numbers of individuals to contact in case of emergency must be posted on the outer surface of each door.

(12) Fire protection procedures must be posted on outer wall near the door.

(13) Cleanup procedures for pesticide spills and for the disposal of contaminated items must be posted.

(14) Presticides must be continually stored in containers that are sound.

(15) All pesticide containers must be labeled and plainly visible.

(16) Combustible materials must be labeled as such.

(17) Pesticide containers must be inspected frequently for deteriorated conditions.

(18) If pesticides are transferred from deteriorated containers to sound containers or from one container to anotner, utilize the same type of container and be sure to label it with the same information that was on the previous one.

(19) *Pesticides must not be stored in empty food or drink containers.*

(20) All pesticide containers must be kept sealed during storage.

(21) Pesticide containers must be stored in rows to permit easy visibility of labels and easy access.

(22) Containers that are 5 gallons or larger must be stored at very low levels.

(23) All glass containers must be stored at low levels in unbreakable encasements.

(24) Pesticides with the least shelf life remaining should be used first.

(25) Pesticide dispersal equipment must be labeled "Contaminated with Pesticides."

(26) Absorptive clay, hydrated lime, or detergents must be available for emergency cleanup of pesticide spills.

(27) Appropriate fire extinguishers must be readily available.

(28) The medical department must be notified, in writing, of the types of pesticides being stored and of their hazards.

(29) The fire department must be provided with a floor plan of each storage area identifying the types and location of the various pesticides.

(30) The fire chief must be provided the home and business telephone numbers of storage custodians, EPA regional administrator, and the Pesticide Safety Team Network of the National Agricultural Chemical Association.

If these general storage precautions are observed at all times, hazards presented by pesticides to the environment, yourself, and others will be reduced greatly.

Exercises (240):

1. Where must a list of chemicals contained within the storage area be posted?

2. What are the requirements for storing excess, illegal, and expired shelf-life pesticides?

3. Exhaust ventilation must be turned on ______ to entering the storage area.

4. Pesticides must continually be stored in containers that are ______.

5. Pesticide containers must be stored in rows to permit ______ visibility of labels and ______ access.

6. What items of equipment must be readily available in storage areas in case of fire?

241. Cite selected pesticide mixing precautions and requirements.

Mixing Precautions. This phase of pesticide handling is very important to you because it is the phase in which you are most apt to be contaminated with the most toxic form of the pesticide. To reduce or prevent possibilities of being contaminated, the following precautions must be observed:

(1) Read the pesticide label and follow the prescribed mixing instructions.

(2) Wear required safety protective equipment (Section 3-3 of this chapter).

(3) Keep children and other unauthorized persons out of mixing area.

(4) Mix pesticides in a well-ventilated area.

(5) Adhere to the "no smoking, eating, or drinking rule" while mixing pesticides.

(6) Mix pesticides in a well-lighted area.

(7) Mix pesticides in an area that is capable of preventing spilled pesticides from contaminating other areas.

(8) Insure that showers and washing facilities are available within the immediate area of mixing for personal decontamination in case of pesticide spills or splashes.

(9) Know the first aid measures to be taken for the pesticide being mixed.

(10) Utilize the buddy system when possible.

(11) Open bagged pesticide containers with a sharp knife instead of tearing.

(12) Close all containers immediately after use and place them back in proper storage.

(13) Keep pesticide containers below eye level during mixing to prevent splashes to the face.

(14) Mix only the amount of formulation needed.

(15) Avoid electrical and fire hazards.

(16) Clean all equipment used during the mixing operation that is not required to be used during the application and hang for drying is necessary.

These precautions that have been identified are the basic precautions to be taken in protecting yourself and others and to prevent property and environmental damage. There are others that you will probably think of, which is good, because the more precautions you take the safer the operation will be.

Exercises (241):

1. Mix pesticides in a well ____________ and ____________ area.
2. Know the ____________ measures to be taken for the pesticide being mixed.
3. Mix only the ____________ of formulation needed.
4. Keep pesticides below ____________ level during mixing to avoid splashes to the ____________.
5. Adhering to mixing precautions is very important because this phase of pesticide handling is the phase in which you are most apt to be ____________ with the most ____________ form of the pesticide.

242. Point out selected pesticide transporting precautions and requirements.

Transporting Precautions. Pesticides can present many hazards to the environment, yourself, and others if they are transported without the knowledge of how to do it safely and without adhering to the basic safety precautions.

The vehicle and the dispersal equipment used in transporting pesticides are important in this phase of handling pesticides, because if the wrong type vehicle and delapidated equipment are used, many hazards are presented.

Each vehicle used for transporting pesticides must be assigned directly to the entomology section and is not to be loaned to other units, because this vehicle has become contaminated with pesticides and will present unnecessary and unwarranted hazards to others.

The vehicle must be the type that contains numerous locked storage compartments for storing various types of pesticides, supplies, equipment, and tools during transport and for conducting entomological operations throughout the base area. Such locked compartments prevent access of any of these items by children and other unauthorized people while unattended by entomology personnel.

To prevent undue exposure to toxic vapors and splashes to driver and passengers, the vehicle must be designed so that these storage compartments are not within the same enclosure that is occupied by the driver and passengers.

In addition to these requirements, the vehicle must provide complete visibility within all directions and be capable of traveling and towing equipment over almost all types of terrain. Complete visibility is necessary to prevent vehicular and pedestrian accidents and to monitor the operation of powered dispersal equipment being towed.

Pesticide dispersal equipment used in transporting pesticides must be in good repair to prevent dripping and splashing of pesticides during the travel, thus reducing contamination of the environment and hazards to children and others.

The following precautions must be observed during the transport phase of pesticide handling:

(1) Read the pesticide label and follow special instructions for transporting pesticides when given.

(2) Wear required safety protective equipment while loading and unloading pesticide equipment.

(3) Keep children and other unauthorized people away from vehicle and equipment.

(4) Label pesticide dispersal equipment as being contaminated with pesticides. Use signs that are large enough to provide easy visibility and one that can be understood by everyone.

(5) Keep all storage compartments locked at all times.

(6) Drive slowly and avoid quick short turns to prevent pesticide spills.

(7) Know the first aid procedures to be taken for pesticides being transported and be oriented at all times as to locations where assistance can be obtained.

(8) Insure that emergency procedures and telephone numbers are available in the vehicle in case of pesticide spills and traffic accidents.

(9) Insure that a CO_2 fire extinguisher is available and secure on the vehicle used for transporting pesticides.

(10) Insure that vehicles and equipment are in safe operational condition.

(11) A container of water should be available on the vehicle for emergency decontamination of eyes and skin in the event of pesticide spills and splashes to the body.

(12) Transport all pesticides in unbreakable containers.

(13) Insure that all pesticide containers being transported, except for equipment, have a complete EPA label on each.

(14) Insure that safety chains and locking pins are in place prior to towing dispersal equipment.

There have been many cases of accidental poisonings that have occurred due to unsafe transporting of pesticides. Most of these poisonings occur to children while the vehicle being used to transport pesticides is left unattended with no safe way to secure it from reach. Remember, you have the responsibility to insure that every precaution available is taken to transport pesticides safely because you are the one who is knowledgeable of the hazards that are presented by pesticides.

Exercises (242):

1. The transporting vehicle must contain numerous __________ compartments for storing pesticides.
2. Keep __________ and other unauthorized __________ away from the transporting vehicle and equipment.
3. Pesticide dispersal equipment used in transporting pesticides must be in good __________ to prevent dripping and splashing of pesticides.
4. Vehicles used for entomological operations must be assigned directly to the __________ section.
5. To identify pesticide dispersal equipment as being contaminated with pesticides, a __________ must be placed on the equipment.
6. Keep all __________ compartments __________ at all times.

243. Specify selected pesticide application precautions and requirements.

Application Precautions. It is in this phase of pesticide handling that most possibilities of contaminating the environment, yourself, and others with pesticide formulations exist. This phase also presents the most possibilities of vehicular and pedestrian accidents.

As though these are not enough hazards presented during the pesticide application phase, there are others, such as fire and electrical hazards; contamination of food and beverages through direct or indirect methods; and causing damage to facilities, facility furnishing, and wearing apparel.

Because of the varied situations that are involved in this phase of pesticide handling, the precautions to be taken will be separated into general, outdoor, and indoor application precautions.

General application precautions. The general application precautions that must be taken are as follows:

(1) Select the most safe and effective pesticide and pesticide formulation for each pest management program.

(2) Read and follow all instructions provided by the pesticide label.

(3) Inspect all safety protective equipment to be used and make necessary corrections.

(4) Wear all required safety protective equipment for the type of pesticide and pesticide formulation to be applied and the operation being performed.

(5) Adhere to the "No smoking, eating, or drinking rule" while applying pesticides.

(6) Know the hazards that may be presented to the environment, property, people, and other nontarget organisms by the pesticide to be used.

(7) Insure that all pesticide spills are promptly cleaned up.

(8) Plan ahead to determine the action to be taken in case of accidental poisoning or other accidents that may be involved in the application of pesticides.

(9) Know first aid measures and antidotes to be taken for the pesticide selected to be used.

(10) Know emergency telephone numbers of medical and fire departments.

(11) Keep a fire extinguisher readily available that is suitable for the type of pesticide formulation being used.

(12) Insure that all areas in which pesticides are being applied are vacated of untrained people while pesticides are being applied.

(13) Insure that a change of clothing, water, and soap is available within the immediate vicinity of where pesticides are being applied in case of contamination.

(14) Select the most safe and effective item of pesticide dispersal equipment to be used for the pesticide formulation and the area in which it is to be used.

(15) Perform a preoperational inspection on equipment to be used to insure that is is operational and does not leak.

(16) Insure that equipment is properly calibrated for the rate of application required.

(17) Insure that equipment being pulled by a vehicle is properly secured with safety chains and lockpins.

(18) Insure there are no obstructions to visibility while applying pesticides. If there are, half operations, and arrange for escort or assistance.

(19) Utilize the buddy system when performing operations that require towing dispersal equipment and the use of highly toxic pesticides.

(20) Apply pesticides only after all hazardous aspects have been analyzed and it has been determined that all foreseeable hazards have been eliminated.

(21) Release all pressure from pesticide dispersal equipment following application.

(22) Clean all equipment that has been used.

(23) Always wash yourself and change clothing following application.

Outdoor application precautions. The following outdoor application precautions must be taken in addition to the general application precautions previously identified:

(1) Know the topography of the terrain to avoid contamination of underground water sources, streams, ponds, rivers, and lakes.

(2) Observe windspeed and direction.

(3) Keep upwind from the direction of pesticide drifts.

(4) Reduce drifts as much as possible.

(5) Avoid contamination of nontarget areas and organisms.

(6) Inform personnel of pesticides that are to be used, the signs and symptoms that are characteristic of the pesticide, and the precautions that can be taken by them when pesticides are being applied within close proximity of their habitations or work areas. NOTE: If the program is to be conducted basewide, notify all personnel by using the Daily Bulletin and/or base newspaper.

(7) Avoid direct application of pesticides to power lines, transformers, and transformer banks.

(8) Avoid traveling over terrain that could overturn vehicles or equipment.

(9) Avoid direct application of pesticides to vehicles, pets, pedestrians, and other people outdoors.

(10) Insure that vehicle and towed equipment lights are operable and on, including emergency flashers, while applying pesticides from roadways.

(11) Be escorted by an escort vehicle while conducting fogging operations within base housing areas.

(12) Do not exceed 5 mph while applying pesticides from vehicles.

If these precautions, along with the general precautions are observed, the outdoor application operations will be much more safe and effective.

Indoor application precautions. The following indoor application precautions must be taken in addition to the general application precautions previously identified:

(1) Prior to indoor application of pesticides, conduct a survey to determine the type and location of pests, degree of infestation, potential hazardous conditions that exist, and the actions that must be taken prior to actual accomplishment.

(2) Make appointments with responsible building occupants as to the date and time that treatment will be accomplished and inform them of the type and characteristics of the pesticide to be used and the precautions and actions that must be taken by them such as building preparations, safe reentry times, and cleanup instructions.

(3) Insure that all dishes, utensils, food containers, food, beverages, stored products, tobaccos, and smoking equipment are removed or covered.

(4) Avoid the application of liquid pesticidal formulations to electrical panel boxes, outlets, switches, lighting, and fires.

(5) Insure that all electricity and heat sources are turned off at the building's primary source when fumigants and volatile formulations are being applied indoors.

(6) Avoid the application of pesticides to interior portions of refrigerators and ovens to prevent toxic vapors of pesticides from being transferred to foods that are contained within.

(7) Do not apply pesticides to closets and drawers unless all items have been removed.

(8) Do not apply residual sprays or dusts to floors and baseboards in areas where small children (infants and toddlers) sleep and play.

(9) Do not apply pesticidal baits in areas that are accessible to children and pets.

(10) Avoid applying pesticides directly overhead by keeping the equipment orifice extended away from and in front of you.

(11) Insure that fish aquariums are turned off and covered or removed, because aquatic organisms are the most sensitive forms of life to pesticides.

(12) Insure that indoor plants are removed or covered when volatile formulations are to be applied indoors.

The application precautions identified in this objective are only the basic precautions that should be adhered to and are not intended to be miscontrued as the only precautions that must be taken. It is to your benefit and others that all of these precautions—along with the ones that you think of and the special ones that are identified on each pesticide container—be observed. It is not only to your benefit; it is your responsibility to follow all precautions possible when applying pesticides.

Exercises (243):

1. When applying pesticides, insure that all pesticide __________ are promptly cleaned up.

2. Insure that the equipment is properly __________ for the rate of application required.

3. When applying pesticides outdoors, reduce __________ as much as possible.

4. In addition to presenting the most possibilities of contaminating the environment, yourself, and others, the application phase of pesticide handling presents the most possibilities of __________ and __________ accidents.

5. Prior to applying pesticides, you should __________ to determine the __________ to be taken in case of accidental poisoning or other accidents that may be involved.

6. The most appropriate general application precaution that offers the best protection against ingestion of pesticides by the operator is also referred to as a rule. What is the rule that is being referenced?

7. If a pest management program is to be conducted basewide, all personnel should be notified. How can this notification be accomplished?

8. To reduce the chances of having an accident within base housing areas while conducting fogging operations, what should be done?

9. What information should be provided to personnel when pesticides are to be applied within close proximity of their habitations or work areas?

244. Point out selected pesticide disposal methods and precautions.

Disposal Methods and Precautions. Although this is the last phase of pesticide handling discussed, it is not any less important than the other phases. Excessive and overextended shelf-life pesticides and excessive and deteriorated pesticide containers must be disposed of in accordance with the instructions provided on the pesticide container label, EPA Standards (40 CFR 165 series), AFR 19-1, and/or AFM 67-1.

Excess stocks of pesticides will be processed in coordination with the local Chief of Supply or the Defense Property Disposal Office in accordance with procedures outlined in AFM 67-1, Volume VI.

Pesticides and pesticide containers that have deteriorated or are unsuitable for return to depot stocks will be destroyed in accordance with procedures outlined in AFR 19-1.

The general disposal precautions for extended shelf-life pesticides and deteriorated pesticide containers are as follows:

(1) Dispose of pesticides and pesticide containers in a specially designated landfill and in accordance with State and local standards.

(2) Provide a list of the pesticides and quantity of each to landfill personnel.

(3) Rinse all pesticide containers, other than paper containers, at least three times prior to disposal.

(4) Destroy all containers, other than aerosol cans, beyond reuse prior to disposal.

(5) Keep all pesticides and pesticide containers properly stored until they can be disposed of.

Now that the safety precautions for storing, mixing, transporting, applying, and disposing of pesticides have been identified, you can see that you have a great responsibility. Not only must you know how to protect yourself, but you must know how to protect the environment, property, and others.

Remember, these precautions are only general guidelines and do not cover all aspects of pesticide handling; therefore, you must follow all instructions provided on each pesticide container label pertaining to special situations.

Exercises (244):

1. Dispose of pesticides and pesticide containers in a specially designated __________ and in accordance with State and local __________.
2. Air Force Manual 67-1, Volume VI, outlines the procedures for disposing of __________ stocks of pesticides.
3. Pesticides and pesticide containers that have deteriorated or are unsuitable for return to depot stocks will be destroyed in accordance with AFR __________.
4. All empty pesticide containers other than paper containers must be __________ at least __________ prior to disposal.
5. Pesticide containers must be properly __________ until they can be disposed of.

245. State the purpose, frequency, and method for conducting pesticide inventories.

Inventory of Pesticides. You should conduct at least once a month a complete inventory of all pesticides that you are responsible for. This inventory should be documented and maintained as an operational shop record. Of course, more frequent inventories are desirable, but these interval inventories would not necessarily have to be recorded.

Inventories serve as a good management tool for all supplies and equipment, and every conscientious pest manager will maintain complete and accurate inventory records.

The purpose for conducting pesticide inventories is threefold; first, it provides an additional security measure; second, it provides the capability of detecting early signs of pesticide container deterioration; and third, it provides an additional means for insuring that pesticides are properly stored.

When pesticide inventories are not conducted regularly, there seems to become a laxity in control, and personnel within the section begin to provide pesticides to their friends and others (who are untrained in proper pesticide use) for use within and around their homes.

Pesticides, especially those that are restricted use pesticides, should never be provided to friends or anyone else, because they do not know the proper way to apply pesticides, nor do they know the proper way to store them. Therefore, you are responsible for any accidents that may occur through ignorance and negligence on the part of the individuals whom you gave the pesticide to.

There are many times that deteriorated conditions of pesticide containers are detected while conducting inventories. If the inventory had not been conducted, the container could have deteriorated to the point of allowing a major spillage of the pesticide, which would have immensely increased potential hazards. However, with early detection of deterioration, the pesticide would be transferred to an approved substitute container and relabeled which reassured safe and proper storage.

In order to maintain an accurate inventory of pesticides you must record all pesticides received between each inventory and the ones that have been withdrawn from the inventory. When the inventory has been completed you should compare the withdrawals with the materials received to insure that the pesticides on hand match the total of the two transactions.

If you have less pesticide on hand than the records indicate, you should conduct another inventory immediately and recheck pesticides withdrawn and received records to determine if a mistake was made. If no mistake is found, then you should expend all efforts to determine why the pesticide cannot be accounted for, especially when the pesticide is very toxic or if the quantity is significant.

Exercises (245):

1. The pesticide inventory serves as a ____________ for good management to conscientious pest managers.

2. When should extreme effort be expended to locate pesticides that cannot be accounted for?

3. Why are pesticide inventories conducted?

4. Should you ever provide pesticides to your friends? Why?

5. When should pesticide inventories be conducted?

6. Explain how to maintain adequate pesticide inventory records.

3-3. Protective Equipment

All personnel who handle pesticides are definitely exposed to the hazards of contamination through inhalation, ingestion, and absorption of pesticide vapors, mists, and dusts.

As an entomology specialist, it is your responsibility to insure that you and your fellow workers wear all required safety protective equipment during all phases of pesticide handling.

In this section, you will become knowledgeable of the various types of safety protective equipment required for the safe handling of pesticides and the directives that outline the responsibilities for insuring that protective equipment is worn.

246. Specify the responsibilities of wearing safety protective equipment.

Responsibilities Outlined. As pointed out in the introduction of this section, it is your responsibility to insure that you and your fellow workers wear all required safety protective equipment during all phases of pesticide handling. However, this responsibility rests not only upon you, but upon all echelons of command, from top to bottom.

This objective will identify pertinent directives that outline the responsibilities for insuring that pesticides are handled safely to include the wearing of required safety protective equipment.

AFR 91-21, Pest Management Program. AFR 91-21 states that each major command will provide for periodic training of base civil engineer personnel engaged in pest management in the safe mixing and application of pesticides. Additionally, this same regulation states that the civil engineer will inspect and determine the safety of pesticide handling and the Director of Base Medical Services will assure that pesticides are handled safely and with appropriate concern for the environment.

AFR 127-101, Ground Accident Prevention Handbook. This regulation states that the use of personal protective equipment will not be used as a substitute for the elimination of unsafe acts and conditions, but rather as a supplemental safety measure. This regulation also states that commanders will direct exposed personnel to wear protective equipment and clothing.

When job requirements specify the wearing of protective equipment (pesticide labels would be an example), this requirement then becomes both a part of safety regulations and a condition of employment.

If military personnel avoid or disregard orders to wear protective equipment, they may be guilty of disobeying a direct order and will be subject to the provisions of the Uniform Code of Military Justice.

Civilian employees who avoid or disregard safety requirements are subject to corrective actions outlined in the civilian personnel manual.

Exercises (246):

1. Who has the responsibility of insuring that you wear the required safety protective equipment?

2. What is one consequence if you fail to wear the required protective equipment prescribed by the pesticide label?

3. Name the Air Force regulation which states that commanders will direct exposed personnel to wear protective equipment and clothing.

4. Who has the responsibility for insuring that periodic training in the safe mixing and application of pesticides is provided to civil engineering personnel engaged in pest management?

5. Who has the responsibility for inspecting and determining the safety of pesticide handling?

6. Personal safety protective equipment is not used as a ____________ but as a ____________ for personal safety.

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7. As outlined in AFR ____________, insurance that pesticides are handled safely and with appropriate concern for the environment is the responsibility of the ________________________________

247. Point out the identification, uses, and maintenance of safety protective equipment in terms of the type, purpose, and/or maintenance procedures.

Items and Maintenance of Safety Protective Equipment Required for Handling Pesticides. There are many items and many types of various items that can be used for protecting the body from pesticides, and the more protection utilized, the less chance you will have of becoming a victim of pesticide poisoning.

Knowing what item of equipment to wear, and wearing it, is not the only important aspect of personal protection, because you may be wearing the proper required equipment and still be poisoned if the equipment has not been fitted and maintained properly. Therefore, it is essential that you know each item of protective equipment that is required to be worn, the purpose of the equipment, and how to maintain this equipment.

Coveralls. Coveralls that cover the entire body should be worn during the mixing and application of pesticides to protect the skin from contamination. Coveralls are authorized for entomology personnel to be worn only while on the job. They are not to be utilized as a replacement for the normal military or civilian dress, which means they are not to be worn to dining facilities, snack bars, base exchange facilities, commissaries, movies, or any other base facility except while performing actual entomological duties.

Coveralls that are worn must be washed separately from other clothing on a daily basis in soap and water. To prevent contamination of other clothing, coveralls that are utilized by entomology personnel must not be sent to the base laundry or public laundry to be washed. Washing machines and dryers are authorized in entomology sections in order for you to maintain your own coveralls in a clean condition at all times.

Another aspect of maintaining coveralls is the frequent inspection to detect holes, tears, and thinning of material. If any of these conditions are detected, the coveralls should be replaced through the supply system.

Waterproof rainsuits. If it is suspected that coveralls will become saturated during the mixing of application of pesticides, you should wear a waterproof rainsuit. These rainsuits can normally be obtained within the supply system and are identified as foul weather gear. This type of protective clothing is very appropriate when handling the more dermally toxic pesticides or if you will be applying liquid pesticidal formulations for long periods at a time.

Maintenance of these rainsuits involves washing with soap and water and hanging up to dry. The rainsuits should be spected frequently for holes and tears and replaced if these discrepancies are noted.

Aprons. A rubber apron should be worn at times while mixing pesticides, especially when large quantities of liquid pesticides are being handled. The apron serves as an additional precaution to prevent the contamination of the pubic region with pesticide. This is very important because this region of the body is the most susceptible external region of the body for pesticide absorption.

To maintain the apron, simply wash with soap and water and inspect it frequently for tears or holes. The apron should be lubricated with vegetable oil periodically to prevent cracking.

Boots. Rubber or neoprene boots should be worn when mixing or applying liquid pesticides, especially if they are being handled on large-scale operations, because leather or canvas boots will absorb liquid pesticides. Boots should be worn with the tops beneath the legs of the coveralls or rainsuit.

Boots can be obtained through the supply system as part of the four weather gear and are maintained by washing with soap and water frequently, inside and out, to remove pesticide contaminant. Rubber boots should also be periodically lubricated with vegetable oil to prevent drying and cracking.

Gloves. Gloves must be worn during all phases of pesticide handling and during the cleaning of dispersal and protective equipment to prevent skin contamination. There are several types of gloves that can be worn, but leather or cotton gloves are not among these types to be worn while handling pesticides. The gloves used must be unlined and liquidproof.

Neoprene gloves are probably the most commonly used glove in pest management operations; however, some fumigants are readily absorbed by neoprene, so be sure to read the label on the pesticide container.

Another type of glove that is popular for use with pesticides is the medical examination glove because it is extremely flexible and is disposable. This glove is not to be used when heavy work is involved because it is very thin and apt to tear easily.

Gloves should fit the hand snugly and should be long enough to extend well above the wrist so that they can be worn beneath the sleeves of coveralls or rainsuits.

Gloves of all types can be obtained through the normal supply system and are maintained by washing with soap and water, inside and out, and inspecting for holes and tears. To inspect for small pinholes and slits, simply fill each glove with water and gently squeeze while holding the top of the glove closed with one hand. If damage is detected, shred the gloves so no one else can use them and dispose of them.

Gloves must be periodically lubricated with vegetable oil to prevent drying and cracking.

NOTE: When disposable gloves are used, they should be shredded and disposed of also. Never dispose of gloves that have been used with pesticides until they have been destroyed beyond the point of reuse.

Hats. A wide-brimmed liquidproof hat should be worn while applying liquid pesticides to protect your head and offer additional protection to the neck, eyes, mouth, and face. The hat should not have a cloth or leather sweatband in it because these sweatbands absorb pesticides and they are very difficult to clean.

The hat is used to protect the head, which is the second most susceptible external region of the body for pesticide absorption. This is due to the large amount of natural body oil that is contained in the hair, and the oil speeds the absorption rate.

The type of hat used by construction workers (plastic hardhat with plastic sweatband) is very good for protecting the head and is available through the supply system. This hat can be easily maintained by frequently washing it with soap and water, inside and out.

Goggles or faceshields. Goggles or a faceshield must be worn while mixing and applying pesticides to protect the eyes. There are times when a faceshield will be more adequate than goggles and vice versa. Just remember to offer your eyes as much protection as possible in each and every circumstance. The biggest disadvantage in using the faceshield is that a respirator cannot be worn comfortably with it, and in most circumstances a respirator of some type is required.

Goggles and faceshields are available through the normal supply system and are authorized for entomology personnel. There are many types of goggles that are available, but when you order them, try to obtain the type that completely encloses the eyes. This type has a tendency to fog over but excludes all possibility of mists and dusts from entering.

To maintain goggles and faceshields wash them with soap and water, inside and out, after each operation. The elastic headbands will absorb pesticides and stretch, so they should be replaced frequently. If goggles are rubber, they should be periodically lubricated with vegetable oil to prevent drying and cracking.

Ear protectors. Ear protective devices such as earplugs or ear muffs must be worn while operating equipment that have been determined as being noise hazardous and while working in areas that present noise hazards.

Maintenance of earplugs amounts to nothing more than keeping them clean by washing in a warm soapy water solution. The ear muffs should be inspected periodically to detect hardening of the rubber pads. These pads must be replaced when hardening is detected.

Respirators and gas masks. Respirators and gas masks are basically the same, but they are generally thought of in a different sense. Most entomology personnel refer to the respirator as the half-face mask that is designed to protect the respiratory system from most harmful pesticidal dusts, mists, vapors, and gases. On the other hand, the gas mask is generally thought of as being the full-face mask that is used when fumigants are being applied or when very toxic pesticides are being applied in an enclosed area.

Since there are many types of respirators and gas masks to choose from, it must be pointed out at this time that the only ones authorized for use are the ones that are approved by either NIOSH (National Institute for Occupational Safety and Health) or MESA (Mining Enforcement and Safety Administration).

Cartridges and canisters for respirators and gas masks must be the type designed to protect against the specific pesticide being used and to fit the specific respirators and gas masks that are available in your section. The incorrect cartridges or canisters for the pesticide being used is as hazardous as having no respiratory protection, just as would having the wrong types of cartridges or canisters for the respirators or gas masks used.

Chemical cartridge respirator. You should wear this kind of respirator when you are only intermittently exposed to toxic pesticides. Air is inhaled through both a filter pad and a cartridge designed to absorb pesticide vapors, gases, and particles.

Chemical canister respirator (gas mask). This respiratory protective device should be worn when you are exposed to a continuous concentration of a toxic pesticide. The canister has longer lasting absorbing material and filters than the cartridge and protects the face better. Neither the canister nor cartridge type can be used when the oxygen supply is low.

Supplied-air respirator (gas mask). You may use this kind of respirator when mixing or applying pesticides:

- When the oxygen supply is low.

When you are exposed to high concentrations of highly toxic pesticides in enclosed areas, as in fumigation.

- When your work can be done close to a supply of clean air.

Clean air is pumped through a hose to the face mask.

Self-contained breathing apparatus (gas mask). You should wear this kind of respirator under the same conditions as the supplied air respirator. It does about the same thing. The difference is that you carry cylinders of air oxygen with you, usually on your back. This lets you move more freely and over a wider area than you can with a supplied air respirator.

The chemical cartridge and the chemical canister respirators are the two most common types of respirators used in Air Force pest management operations. Although all types are available through normal Air Force supply systems, the cartridge and canister types are more easily obtained. The supplied-air respirator and the self-contained breathing apparatus can be obtained with proper justification, but if they are only needed once in awhile, they can be obtained from the Fire Department or Environmental Support Section on a Temporary Issue Receipt (AF Form 1297).

To maintain respiratory protection devices, wash all rubber surfaces and plastic faceshields with soap and water after use. Rubber surfaces should be lubricated with vegetable oil periodically to prevent the rubber from drying and cracking.

Cartridges and canisters must be discarded when odors are detected in them or once it becomes unusually difficult to breathe through them. The expiration date on cartridges and canisters must also be checked to insure that the expiration date has not been exceeded. If so, these items are not to be used and must be discarded immediately.

Each person assigned to an entomology section should be issued coveralls, boots, gloves, goggles, respirator, and a hat to be maintained separately from uncontaminated equipment and clothing in personal lockers. These items of protective equipment are to be maintained by each individual.

Rubberized protective equipment should be stored in a cool dark area if the storage is to be a prolonged one.

Items of safety equipment required to be worn is dependent upon the type of pesticide being handled, the phase in which it is being handled, and the method in which it is being applied. There are no safety recommendations that can cover all situations; therefore, it is your responsibility to read and follow the instructions provides on each pesticide container label and use common sense in wearing more protection as the hazards increase for handling pesticides.

Exercises (247):

1. What restrictions apply to wearing coveralls?

2. What pieces of equipment are authorized in entomology sections to maintain your coveralls in a clean condition at all times?

3. What item of protective clothing would be worn if it is suspected that coveralls will become saturated with pesticide?

4. If you are applying liquid pesticidal formulation for long periods at a time you will wear a ________ .

5. When mixing large quantities of liquid pesticides you should wear an ________ .

6. The most susceptible external region of the body for pesticide absorption is the ________ region.

7. How should boots be worn?

8. When must gloves be worn?

9. A wide-brimmed liquidproof hat should be worn while applying ________ pesticides.

10. What is worn to protect the eyes when mixing or applying pesticides?

11. When working in areas where noise may be hazardous you must wear ________ .

12. The only gas mask or respirators authorized for use are approved by ________ and ________ .

13. Cartridge and canister must be discarded when ________ are detected or it becomes difficult to ________ through them.

14. To maintain respiratory protective devices, wash all rubber surfaces and plastic faceshields with ________ and ________ .

15. Rubber surfaces should be lubricated with ________ oil to prevent the rubber from ________ and ________ .

3-4. Pesticide Poisoning Symptoms and First Aid

From the previous exercise it can readily be seen that pesticides are toxic and present hazards to people in many ways, either directly or indirectly through ignorance, which leads to negligence.

Negligence leads to many problems. These problems may be minor or major, but in any event we must be knowledgeable enough to render assistance in overcoming this problem.

The problem which we are referring to is accidental pesticide poisoning. As you have already learned, a person may become poisoned through ingestion, absorbtion, and inhalation.

This section is devoted to the recognition of signs and symptoms of various types of pesticide poisoning and the accomplishment of first aid procedures based upon the type of pesticide and the method of entry.

248. Identify the compound that is described by the mode of action statement.

Modes of Action of Common Pesticide Compounds. The methods in which pesticides affect humans and other mammals are commonly referred to as *modes of action*. The modes of action of many pesticides in use today are either unknown or, in some instances, are only partially understood. However, medical research does provide sufficient information to permit certain generalizations.

Information pertaining to the methods in which pesticides affect humans and other mammals are given for the following compounds.

Organophosphates. These pesticides attach themselves to cholinesterase, an enzyme in the blood, which is normally present and required for proper nerve function. Since the action of organophosphorus pesticides restrain the enzyme cholinesterase, they are referred to as "cholinesterase inhibitors" or "anticholineasterase compounds."

Carbamates. These compounds are very similar to the organophosphorus compounds with regard to the modes of action. Carbamates also inhibit the enzyme cholinesterase; however, they differ in action in that the effect on cholinesterase is very brief because the carbamates are quickly broken down in the body. Carbamates are referred to as "rapidly reversing inhibitors" because the reversal is so rapid that, unless special precautions are taken, samples of blood cholinesterase of mammals that have been exposed to carbamates commonly will be inaccurate, appearing to be normal.

Organochlorines (chlorinated hydrocarbons). The exact modes of action of these compounds is not known; however, they do act on the central nervous system, and repeated doses can cause liver and kidney damage in animals.

Botanicals. The botanical compounds must be divided because the modes of action vary greatly based upon chemical structure and toxicity to humans.

a. Pyrethrum. Pyrethrum is one of the least toxic pesticides available. The extent of injury to humans usually results in minor skin allergies, sneezing, and runny or stuffy nose.

b. Strychnine. This chemical is know to effect the nervous system and in some instances causes extreme nervousness. The exact mode of action is still not completely understood.

c. Nicotine. This chemical is one of the most toxic poisons and the action is very rapid. Nicotine acts on the nervous system and in extreme cases causes paralysis of the respiratory muscles which results in death.

Petroleums. Petroleums such as kerosene, diesel oil, and No. 2 fuel oil have been used as mosquito larvicides for many years. Research indicates these oils have a toxic fraction with a low boiling point and high volatility which penetrates the tracheae of larvae and pupae and produces an anaesthetic effect, and a less volatile fraction which acts more slowly and generally does not have any direct toxic action, but suffocates by mechanical interference with breathing.

Fuel oil No. 2 and diesel oil are the commonest solvents for the synthetic insecticides such as malathion used for larviciding, fogging, or misting. In making emulsifiable concentrates and formulations for airplane applications, it is often desirable to use a higher concentration of these insecticides than can be dissolved in these oils, so an auxiliary solvent, such as xylene, is used.

Petroleums may be absorbed orally or through the respiratory tract but are only slightly absorbed dermally. When sufficient quantities are ingested or inhaled by humans it can cause severe aspiration and occlusion of the respiratory system and may cause pneumonia or death.

Fumigants. The modes of action of fumigents are varied; therefore, the fumigants that are commonly used within the Air Force will be discussed individually.

a. Methyl bromide. This compound is among the most hazardous of the chemical compounds. Methyl bromide affects the protein molecules within certain cells of the body and causes severe kidney damage.

b. Hydrogen phosphide. Hydrogen phosphide is highly toxic to all forms of animal life, and the mode of action is the result of interference or inhibition of important cellular enzyme systems vital to the oxygen transport mechanisms of the body.

c. Hydrogen cyanide (calcium cyanide). Hydrogen cyanide can be inhaled or ingested and can increase excretion of thiocyanate in the urine which can result in cytotoxic anoxia.

Anticoagulants. These compounds cause capillary damage and inhibit the formation of prothrombin which prevents the clotting of blood. This causes internal bleeding after repeated dosages have been consumed.

Exercises (248):

1. What compound inhibits the formation of prothrombin which prevents the blood clotting process?

2. Name the botanical compound that is considered to be one of the least toxic pesticides.

3. Two compounds that inhibit or restrain the enzyme cholinesterase are ____________ and ____________.

4. What compound affects the protein molecules within certain cells of the body and causes severe kidney damage?

249. Identify the pesticide compound that is described by the signs and symptoms of pesticide poisoning.

Signs and Symptoms of Pesticide Poisoning. You should know what kinds of sickness are caused by the pesticides you use. You also should know the conditions under which each one may make you sick.

There are two kinds of clues to pesticide poisoning. Some are feelings that only the person who has been poisoned can notice—such as nausea or headache. These are *symptoms.* Others, like vomiting, also can be noticed by someone else. These are *signs.* So you should know:

- What your own feelings might mean.
- What signs of poisoning to look for in your coworkers and others who may have been exposed.

All pesticides in the same chemical group cause the same kind of sickness. This sickness may be mild or severe, depending on the pesticide and the amount absorbed. But the *pattern* of illness caused by one type of pesticide is always the same. Having some of these signs and symptoms does not always mean you have been poisoned. Other kinds of sickness may cause similar signs and symptoms. Headache and a feeling of being unwell, for example, may signal the start of many kinds of illness. It is the *pattern* of symptoms that makes it possible to tell one kind of sickness from another, which is the subject of this topic as we discuss various chemical compounds.

Organophosphates. These pesticides injure the nervous system. The signs and symptoms go through stages. They normally occur in this order:

a. Mild Poisoning.
- Fatigue.
- Headache.
- Dizziness.
- Blurred vision.
- Too much sweating and salivation.
- Nausea and vomiting.
- Stomach cramps or diarrhea.

b. Moderate Poisoning.
- Unable to walk.
- Weakness.
- Chest discomfort.
- Muscle twitches.
- Constriction of pupil of the eye.
- Earlier symptoms become more severe.

c. Severe Poisoning.
- Unconsciousness.
- Severe constriction of pupil of eye.
- Muscle twitches.
- Secretions from mouth and nose.
- Breathing difficulty.
- Death if not treated.

Illness may be delayed a few hours. But if signs or symptoms start more than 12 hours after you were exposed to the pesticide, you probably have some other illness. Check with your physician to be sure.

Carbamates. The only carbamates likely to make you ill on the job act almost like organophosphates. They produce the same signs and symptoms if you are poisoned by them. But the injury they cause can be corrected more easily by a physician. For this reason, most carbamates are safer than organophosphates. The label will warn you of the danger.

Organochlorines. Not many organochlorines (chlorinated hydrocarbons) have poisoned applicators.

Early signs and symptoms of poisoning include:
- Headache.
- Nausea.
- Vomiting.
- General discomfort.
- Dizziness.

With more severe poisoning, convulsions follow. They may even appear without the warning symptoms. Coma may follow the convulsions. The person also may be unusually excited or irritable.

Botanicals. Botanicals are pesticides that have been made from plants, and some are very toxic and cause different reactions depending on the type of chemical which we are about to study.

a. Pyrethrum. The signs and symptoms of this poison in early stages usually result in:
- Skin irritation.
- Sneezing.
- Runny nose.

More severe poisoning symptoms may include headaches, tremors, and convulsions.

b. Strychnine. Signs and symptoms of this type poisoning include:
- Nervousness.
- Stiffness of face and leg muscles.
- Cold sweat.
- Falling asleep.

A victim may undergo as many as 10 of these attacks before either recovering or dying. Usually a victim will succumb if medical aid is not obtained before five of these convulsions occur. If a victim withstands the first 5 to 6 hours, chances of recovery are good.

c. Nicotine. Poisoning from this chemical is recognized by:
- Local skin burns.
- Skin irritation.
- Extreme stimulation.
- Extreme excitableness.

These signs and symptoms are usually followed by feeling depressed. In fatal cases, death usually occurs within 1 hour due to paralysis of the respiratory muscles.

Petroleums. Too much exposure to these compounds may make a person seem drunk. The signs and symptoms are:
- Poor coordination.
- Slurring words.
- Confusion.
- Sleepiness.

Repeated exposure to these compounds can cause permanent internal injury.

Fumigants. These compounds may present the same signs to humans as the petroleums. The signs and symptoms for common fumigants are provided below.

a. Methyl Bromide. This compound may make a person seem drunk. The signs and symptoms are:
- Poor coordination.
- Slurring words.
- Confusion.
- Sleepiness.

Repeated exposure to the fumigant methyl bromide has caused permanent internal injury without early signs or symptoms of poisoning. You can absorb a fatal dose of it before symptoms appear.

b. Hydrogen Phosphide. The early symptoms of hydrogen phosphide poisoning are acute, obvious, and readily reversible. Overexposure of hydrogen phosphide results in:
- Tightness in the chest and diaphragm.
- Vomiting.

- Diarrhea.
- Numbness.
- Anxiety.
- Dry coughs.

In cases of severe poisoning, victims may experience cyanosis, muscular spasms, and cardiac insufficiency.

c. Hydrogen Cyanide. The signs and symptoms for this fumigant are as follows:

- Headache.
- Weakness.
- Nausea.
- Vomiting.
- Increased rate of respiration.
- Depression.
- Rapid but weak pulse.

In cases of severe poisoning, victims may experience cyanosis and convulsions, which may result in death.

Anticoagulants. Anticoagulant poisoning may be recognized by experiencing pain to the back and abdominal area. Vomiting and nosebleeding usually occurs because anticoagulants are designed to induce vomiting and prevent the blood from clotting. Victims may have a skin rash appear in the form of red patches along with unexplainable bruises around the elbows and knees.

Now that you are aware of the effects of some chemical compounds, keep in mind that everyone is subject to various diseases and sicknesses. Therefore, individuals who work with pesticides may not actually be poisoned even though they may appear to have some of the signs and symptoms. However, we must be alert.

Get medical advice quickly if you or any of your fellow workers have unusual or explained symptoms starting at work or later the same day. If you suspect a person has been poisoned, do not leave him alone. Do not let yourself or anyone else get dangerously sick before calling your physician or going to a hospital. It is better to be too cautious than too late. Take the container (or the label) of the pesticide to the physician. Do not carry the pesticide container in the passenger space of a car or truck.

Exercises (249):

1. Name a pesticide that might cause skin irritations, sneezing, and a runny nose.

2. Tightness in the chest, vomiting, diarrhea, numbness, anxiety, and dry coughs are the signs and symptoms of overexposure to which compound?

3. A compound that produces bacially the same signs and symptoms that are produced by organophosphate compounds is a ____________.

4. Descrive the difference between a "sign" and a "symptom" with reference to pesticide poisoning.

5. List only the signs that may be presented in the case of mild poisoning by organophosphate compounds.

6. The reason that most carbamate pesticides are considered safer than organophosphate pesticides is that injury by carbamates can be ____________ ____.

7. The two compounds that present the same signs and symptoms that are characteristic of a drunk person are ____________ and ____________.

8. A person experiencing pain to the back and abdominal area, vomiting, and nosebleeding may have ____________ poisoning.

250. Identify methods in which accidental pesticide poisonings occur in terms of the appropriate measure to be taken to prevent them.

How Accidental Pesticide Poisonings Occur. We, as humans, are considered to be the most intelligent of all animal forms, so it seems that no one should be dumb enough to become poisoned by pesticides. However, there are many cases of human pesticide poisonings reported each year, and there are many more that are not reported because they have not been severe enough to cause recognition by individuals.

Most all pesticide poisonings occur accidentally through actions on the part of supposedly intelligent human beings. If we are so intelligent why and how do pesticide poisoning accidents occur? This question can be answered by two words, *ignorance* and *negligence.*

It has already been pointed out that pesticides can poison people through ingestion, absorption, and inhalation, but the methods by which these pesticides are accidentally ingested, absorbed, and inhaled have not been pointed out. The purpose of this objective is to identify the methods by which these poisons are accidentally taken into the body and to identify measures that can be taken to prevent these accidents.

How pesticide poisoning accidents occur through ingestion. Accidental ingestion of pesticides occurs through the following methods:

- Sprays and dusts enter the mouth during application.
- Pesticides are consumed from unlabeled or contaminated containers, such as beverage and milk containers.
- Siphoning pesticides by the mouth in transferring from one container to another.
- Eating or drinking items that have been contaminated with pesticides.

Prevention for accidental pesticide ingestion. The following measures can be taken to prevent accidental ingestion of pesticides:

- Insure that the area being treated is vacated by other personnel during application.
- Insure that respirators or masks are worn by operators.
- Insure that all containers used for storing pesticides are clearly and properly labeled at all times.
- Store all pesticides in a secure area and out of reach of children.
- Insure that all consumable products and wares are removed or properly covered when pesticides are being applied within the same area.
- Insure that the no smoking, eating, or drinking rule is complied with during all phases of pesticide handling.
- Never employ the mouth for siphoning pesticides.

How pesticide poisoning accidents occur through absorption. Accidental absorption of pesticides occurs through the following methods:

- Pesticides settle on the skin during application and are absorbed.
- Spilling or splashing pesticides on clothing and skin during mixing, transporting, and/or application.
- Entry into treated areas too soon after application and coming in contact with recently applied or spilled pesticides.
- Pesticide containers (empty or with contents) left insecure or undisposed of, permitting reuse or use as play objects for children.
- Maintaining contaminated pesticide equipment.

Prevention for accidental pesticide absorption. The following measures can be taken to prevent accidental absorption of pesticides:

- Insure that the area being treated is vacated by other personnel during application.
- Store all pesticides in a secure area.
- Insure that coveralls, gloves, boots, goggles, and hats are worn during application and aprons are worn in addition while mixing.
- Mix, transport, and apply pesticides carefully to avoid spills and drips.
- Clean up pesticide spills immediately.
- Observe the no smoking, eating, or drinking rule while handling pesticides.
- Allow sufficient time for pesticide residuals to dry before reentry is allowed.
- Properly discard or secure empty pesticide containers.
- Secure partial or full pesticide containers so that unauthorized personnel cannot obtain them.

How pesticide poisoning accidents occur through inhalation. Accidental inhalation of pesticides occurs through the following methods:

- During storage, mixing, and application.
- Unsecured or occupied areas that are being treated.
- Smoking contaminated smoking supplies.

Prevention for accidental pesticide inhalation. The following measures can be taken to prevent inhalation of pesticides:

- Store pesticides in a well-ventilated area.
- Store all pesticides in a secure area.
- Inspect containers for deterioration.
- Mix pesticides in a well-ventilated area.
- Observe the no smoking, eating, or drinking rule while handling pesticides.
- Wear approved gas masks or respirators while mixing or applying pesticides.
- Temporarily vacate and secure areas that are being treated.
- Properly identify areas that are being fumigated.
- Comply with the no smoking, eating, or drinking rule while applying pesticides.
- Discard or secure pesticide containers.

Exercises (250):

Match the methods of accidental poisoning with the appropriate preventive measure.

Methods of Poisoning	*Preventive Measures*
______ 1. Pesticides are drunk from beverage containers.	a. Prevent reentry into treated areas until residuals are dry.
______ 2. Pesticides are ingested while applying sprays and dusts.	b. Insure that areas where pesticides are kept are properly ventilated.
______ 3. Pesticides are absorbed by children through contact with unevaporated residuals.	c. Always wear appropriate respirators for jobs being accomplished.
______ 4. Pesticides are inhaled within the storage area.	d. Adhere to the no smoking, drinking, or eating rule.
______ [illegible]. Pesticides are ingested by the operator during application even though all required protective equipment was being worn at the time.	e. Insure that pesticides are only stored in their proper container at all times.

6. The two basic causes of all accidental pesticide poisonings occur through ______________ and ______________.

7. List the two preventive measures that appear in each of the three groups of preventive measures.

251. Given pesticide poisoning situations, list the procedural steps that should be followed in rendering first aid to victims of poisoning; specify responsibilities and basic guidelines for giving first aid.

First Aid Procedures for Suspected Pesticide Poisoning. As an entomology specialist, you are responsible to plan ahead by anticipating possibilities of accidental pesticide poisoning and establishing actions to be taken in the event poisoning does occur.

If you are alone in the field with an individual who becomes sick, or if you become sick while applying pesticides, cease operations immediately and proceed to obtain the nearest professional medical assistance.

In the event you are alone with an individual who has become acutely poisoned with pesticides in the field and a vehicle is available, transport the victim immediately to a facility that has a telephone or professional medical assistance, depending upon the condition of the victim and proximity of the facilities.

Each and every individual is obligated to do whatever can be done to save a human life when called upon to render first aid. Your first responsibility in rendering first aid is to keep the victim alive, and the second is to seek professional medical assistance as soon as possible.

Being a pest manager, you must know the first aid procedures for pesticide poisoning, because it's very possible that you may be the first to arrive at a scene of pesticide poisoning, and you will be required to render first aid to the victim. Or you could even be the victim of accidental pesticide poisoning yourself. In either case, you must know what to do and how to respond to the situation. Remember that first aid is only a measure to save a victim until professional medical assistance can be obtained and is not to be substituted for professional medical assistance.

The primary purpose of first aid is to prevent further absorption of a poison, which means that aid must be given immediately. The intent of this objective is to provide you with procedural steps that can be taken in circumstances which involve pesticide poisonings that occur through absorption, inhalation, and ingestion, if you happen to be the victim, or alone with a victim.

First aid procedures if you are the victim. Prior to using any pesticide, it is important to read the directions in the "Statement of Practical Treatment" on each pesticide container label. These instructions can save your life and the lives of your fellow workers.

a. Self first aid for absorbed pesticides. If you get a pesticide on your skin:

First—Remove the pesticide as quickly as possible. NOTE: This may require you to jump immediately into a shower or waterhole, clothes and all.

Second—Remove all contaminated clothing and wash your entire body thoroughly to include the hair, eyes, ears, and under the fingernails.

Third—Obtain medical attention for examination and to alert the staff for possible side effects.

b. Self first aid for inhaled pesticides. If you accidentally inhale pesticides:

First—Vacate the area and get to fresh air immediately.

Second—Obtain medical attention for examination and to alert the staff for possible side effects.

c. Self first aid for ingested pesticides. If you accidentally ingest pesticides:

First—Rinse your mouth with plenty of water.

Second—If the "statement of practical treatment" on the pesticide label recommends a general antidote, administer at once.

Third—Obtain medical attention immediately.

First aid procedures if you are alone with a victim. As a general rule, from the safety standpoint, you should never apply the more toxic pesticides alone. You should always operate under the "buddy system" just as it is suggested when hiking or swimming, because one never knows when an accident may occur. If an accidental pesticide poisoning does occur to a fellow worker, you should know the first aid procedures and follow them step by step. There are many circumstances that may be involved in accidental poisonings such as the victim being poisoned through absorption, inhalation, and/or ingestion and being conscious or unconscious with or without readily available medical assistance. Therefore, recognition of these circumstances and your speed and accuracy in reaction to these circumstances is your responsibility and could mean the difference in life or death to your fellow worker and a clean conscience for yourself.

a. When pesticide poisoning by skin absorption is suspected. If the *victim is unconscious* and *medical assistance is not readily available* by telephone, follow these steps:

First—Don gloves and remove the victim from the contaminated area by carrying, using extreme caution to avoid self-contamination.

Second—Determine if the victim is breathing; if not, administer back pressure-armlift artificial respiration immediately; and if breathing (or once the victim's breathing has been restored), decontaminate the victim by drenching the entire body, clothes and all, with a shower, hose, or waterhole.

Third—Treat the victim for shock.

Fourth—Determine the type of pesticide absorbed if possible.

Fifth—Obtain medical assistance as rapidly as possible and provide the medic with all information possible pertaining to the victim's condition, the first aid measures rendered, and the type of pesticide absorbed or suspected to have been absorbed.

If the *victim is unconscious* and *medical assistance is readily available* by telephone, follow these procedures:

First—Don gloves and remove the victim from the contaminated area by carrying, using extreme caution to avoid self-contamination.

Second—Determine if the victim is breathing; if not, administer back pressure-armlift artificial respiration immediately; and if the victim is breathing (or once breathing has been restored), decontaminate the entire body in the same manner as previously described.

Third—Treat the victim for shock.

Fourth—Call for medical assistance and provide all details possible at this time concerning the incident.

Fifth—Determine the type of pesticide responsible for the poisoning and remain by the victim to monitor conditions and to provide information to the medic.

If the *victim is conscious* and *medical assistance is not readily available* by telephone, follow these steps:

First—Don gloves and remove the victim from the contaminated area by carrying, using extreme caution to avoid self-contamination.

Second—Decontaminate the victim by drenching the entire body.

Third—Treat the victim for shock.

Fourth—Determine the type of pesticide absorbed if possible.

Fifth—Obtain medical assistance as rapidly as possible and provide the medic with all information possible pertaining to the victim's condition, the first aid measures rendered, and the type of pesticide absorbed or suspected to have been absorbed.

If the *victim is conscious* and *medical assistance is readily available* by telephone, follow these steps:

First—Don gloves and remove the victim from contaminated area by carrying, using extreme caution to avoid self-contamination.

Second—Decontaminate the victim by drenching the entire body.

Third—Treat the victim for shock.

Fourth—Call for medical assistance and provide all information possible at this time pertaining to the incident.

Fifth—Determine the type of pesticide responsible for the poisoning, if not already known, and remain by the victim to monitor conditions and to provide additional information to the medic.

b. When pesticide poisoning by inhalation is suspected.

If the *victim is unconscious* and *medical assistance is not readily available* by telephone follow these steps:

First—Don air-supplied respirator and remove victim to fresh air, if in an enclosed area.

Second—Loosen all tight clothing.

Third—Determine if victim is breathing; if not, administer back pressure-armlift artificial respiration immediately.

Fourth—If victim is breathing, or once breathing has been restored, treat for shock.

Fifth—Determine the type of pesticide involved in the incident if possible.

Sixth—Obtain medical assistance as rapidly as possible, keeping the victim quiet and warm and monitoring the victim's condition.

If the *victim is unconscious* and *medical assistance is readily available* by telephone, follow these steps:

First—Don air-supplied respirator and remove victim to fresh air if in an enclosed area.

Second—Loosen all tight clothing.

Third—Determine if victim is breathing; if not, administer back pressure-armlift artificial respiration immediately.

Fourth—If victim is breathing, or once breathing has been restored, call for medical assistance.

Fifth—Treat the victim for shock.

Sixth—Determine the type of pesticide involved in the incident if possible.

Seventh—Remain with victim to monitor the victim's condition and to provide information to the medics pertaining to the incident.

If the *victim is conscious* and *medical assistance is not readily available* by telephone, follow these steps:

First—Don air-supplied respirator and remove victim to fresh air if in an enclosed area.

Second—Loosen all tight clothing.

Third—Treat the victim for shock.

Fourth—Determine the type of pesticide involved in the incident if possible.

Fifth—Obtain medical assistance as rapidly as possible while monitoring the victim's condition.

If the *victim is conscious* and *medical assistance is readily available* by telephone, follow these steps:

First—Don air-supplied respirator and remove victim to fresh air if in an enclosed area.

Second—Loosen all tight clothing.

Third—Call for medical assistance.

Fourth—Treat the victim for shock.

Fifth—Remain with victim to monitor the victim's condition and to provide information to the medics pertaining to the incident.

c. When pesticide poisoning by ingestion is suspected.

If the *victim is unconscious* and *medical assistance is not readily available* by telephone, follow these steps:

First—Determine if victim is breathing; if not, administer back pressure-armlift artificial respiration.

Second—Obtain medical assistance as rapidly as possible if victim is breathing or once breathing has been restored.

Third—During transport to, or while waiting for medical assistance, treat the victim for shock and monitor the victim's condition at all times.

If the *victim is unconscious* and *medical assistance is readily available* by telephone, follow these steps:

First—Call for medical assistance.

Second—Determine if victim is breathing; if not, administer back pressure-armlift artificial respiration.

Third—Treat the victim for shock.

Fourth—Determine the type of poison ingested if possible and remain with the victim until medical assistance arrives.

Fifth—Once medical assistance has arrived, provide all the information possible pertaining to the type of poison ingested and first aid measures that have been administered.

If the *victim is conscious* and *medical assistance is not readily available* by telephone, follow these steps:

First—Obtain medical assistance as rapidly as possible by transporting to a hospital or physician.

Second—During the process of obtaining medical assistance, monitor the victim closely.

Third—If victim loses consciousness, check breathing; and if not, administer back pressure-armlift artificial respiration.

Fourth—Once victim's breathing has been restored, proceed for medical assistance and provide the medics with all information possible pertaining to the incident.

If *victim is conscious* and *medical assistance is readily available* by telephone, follow these steps:

First—Call for medical assistance.

Second—Determine the type of pesticide ingested if possible.

Third—Administer the recommended antidote if there is one and if it is available.

It is recognized that the first aid procedures outlined in this objective do not cover all pesticide poisoning situations and that they are not absolute. However, they do provide you with a basis for rendering first aid to a poisoned victim. There are many circumstances in which you may be required to react on your own common knowledge of first aid and the circumstances involved at that time.

Exercises (251):

1. A victim is suspected of being poisoned with a fumigant, is unconscious and breathing, and medical assistance is not readily available. The first aid procedures to be taken are the following.

2. A victim is suspected of being poisoned by absorbing pesticides, is conscious, and medical assistance is readily available. The first aid procedures to be taken are as follows:

3. A victim is suspected of being poisoned by the ingestion of a pesticide, is unconscious and not breathing, medical assistance is not readily available by telephone. The first aid procedures to be taken are as follows:

4. If you happen to spill pesticides on your body, what is the *first* step that you should take in rendering first aid to yourself?

5. Why should medical attention be obtained even though poisoning is not expected to be severe?

6. What is the most important source for obtaining first aid instructions for each pesticide?

7. What responsibility rests upon you as an Entomology Specialist prior to applying any pesticide?

8. (a) What is your first responsibility in rendering first aid?

   (b) What is your second responsibility?

9. First aid is not to be substituted for ________ ____________________________.

10. Recognizing the fact that all pesticide poisoning situations cannot be predicted and the first aid procedures to be applied in any given situation are not absolute, how may you be required to react?

11. The first aid procedures to be taken for accidental pesticide poisoning depends upon the ________ involved at the time.

12. The type of artificial respiration to be administered to a victim of pesticide poisoning is the ____________ type.

252. Identify the types of antidotes to be administered for specific pesticides and the precautions to be taken for pesticide poisoning situations.

Antidotes for Accidental Pesticide Poisoning. Many antidotes have already been discussed in previous objectives because an antidote is defined as a remedy used to counteract effects of a poison or prevent or relieve poisoning. Therefore, the safety precautions for storing, mixing, transporting, and applying pesticides and a knowledge of first aid, are in ways antidotes because they can prevent or relieve poisoning.

Discussion within this objective will be devoted to providing special warnings in the use of antidotes for certain types of poisons and in certain situations and to identify antidotes that are given orally or intravenously for common pesticides.

Special warnings for oral antidotes. There are times and certain types of poisons in which oral antidotes must not be given to a victim of accidental poisoning because they could and most probably would cause more damage to the victim. It is your responsibility to know when and when not to administer an antidote for specific types of poisoning. Special warnings for administering antidotes are as follows:

- Most toxic chemical labels provide first aid instructions ("Statement of Practical Treatment" on pesticide labels) for that particular chemical. Therefore, if the container for the poison known to be responsible for the accidental poisoning is readily available, it is imperative that you read these instructions prior to administering anything orally.
- Never give anything orally to an unconscious victim.
- You should never induce vomiting if the victim is unconscious or is in convulsions.
- You should never induce vomiting if the victim has swallowed petroleum products such as kerosene, gasoline, and diesel fuel, or has swallowed corrosive poisons such as lye, acids, and lysol.
- Vomiting should be induced when noncorrosive substances have been swallowed, if the victim is conscious and not convulsive.

Antidotes for common pesticide compounds. There are several household items normally found within the home that can be used as antidotes for poisons, and the item that should be used depends upon whether or not vomiting is to be induced. The antidotes given at home or on the job are only temporary measures, and their effects on the victim of accidental pesticide poisoning is dependent upon the speed in which they are given. Antidotes that have been given at home or on the job are not to be substituted for professional medical treatments.

Some household items and their uses as antidotes for poisons are as follows:

- Clean water can be used as a diluent.
- Salt water can be used as a diluent and emetic.
- Milk can be used as a diluent or neutralizer of acid or alkali poisons.
- Milk of magnesia can be used as a neutralizer of acid poisons.

NOTE: Before any of these items are used as antidotes remember the "special warnings" that were given at the beginning of this objective.

The *universal antidote* is used for a wider variety of commonly used pesticides than any other antidote. This antidote is given orally in cases of poisoning by the following pesticide compounds:

- Organochlorines (chlordane, Dieldrin, lindane, etc.).
- Phenoxys (2, 4-D, 2,4,5-T, and 2,3,6-TBA, etc.).
- Hydrogen cyanide (calcium cyanide).
- Pentachlorophenol.
- **Nicotine sulfate.**
- **Sodium fluoroacetate.**

NOTE: The universal antidote has only a slight possibility in counteracting sodium fluoroacetete. Although the possibility is slight, it is better than none at all, but there is still no proven effective antidote for sodium fluoroacetate.

The universal antidote can be prepared by a pharmacist by mixing 2 parts activated charcoal, 1 part magnesium, 1 part oxide, and 1 part tannic acid. This mixture is then administered as 1/2 ounce per 1/2 glass of warm water.

NOTE: A homemade universal antidote can be prepared by using 4 tablespoons of crumbled burned black toast; 2 tablespoons of strong tea, and 2 tablespoons of milk of magnesia.

Atropine is the specific antidote for organophosphate pesticides such as the chemicals contained in the Diazinon, Malathion, and Parathion groups and the carbamate pesticides such as carbaryl and Propoxur. Atropine can be administered intravenously or orally.

An antidote that is frequently used in conjunction with atropine to counteract organophate poisoning is 2-PAM. However, it must not be used for carbamate poisoning.

Vitamin K is the antidote to be used in counteracting anticoagulant poisons such as warfarin, Diaphacin, and Pival. This antidote must be administered by a physician.

BAL is a specific antidote to be used for arsenical poisons. This antidote can be obtained from a pharmacist but must be injected by a physician.

Now that you are aware of the requirements for handling pesticides safely at all times and guidelines have been furnished in the prevention of pesticidal accidents, you should be capable of avoiding the unwarranted destruction of property, contamination of the environment, and human poisoning.

In the event that poisoning does occur to humans by pesticides, you now have the basic knowledge for keeping victims alive until professional medical assistance is obtained.

Exercises (252):

1. An antidote for pesticide poisoning should never be administered until the type of __________ responsible for the poisoning is known.

2. You must never administer anything orally to an __________ victim.

3. For what circumstances can vomiting be induced?

4. When should vomiting not be induced?

5. Antidotes that are given in the home or on the job are only __________ measures and should never be substituted for ______________ treatment.

6. The degree of results in administering proper antidotes is dependent upon the __________ in which they are given.

7. List two common household items that are identified in the text that can be used as neutralizers for some pesticide poisonings.

8. The specific antidote for organophosphate poisoning is __________, and this antidote can be used as an antidote for carbamate poisoning.

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9. List the ingredients and the amount of each ingredient required in preparing the homemade universal antidote.

10. The pharmaceutical universal antidote is given orally to counteract what pesticidal compounds?

11. What antidote can be used for organophosphates but not for carbamates?

12. Name the antidote that can be obtained from a pharmacist but must be administered by a physician for arsenical poisoning.

13. Vitamin K is the antidote that must be administered by a physician to counteract __________ poisoning.

14. Based upon what you have read in previous discussions of pesticide characteristics, what is the function of Vitamin K?

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APPENDIX

APPENDIX A. ARTHROPODS OF PUBLIC HEALTH IMPORTANCE: KEY TO COMMON CLASSES AND ORDERS

APPENDIX A

1. Three or 4 pairs of walking legs (Fig. 1 A & B) 2

Five or more pairs of walking legs (Fig. 1 C & D) 33

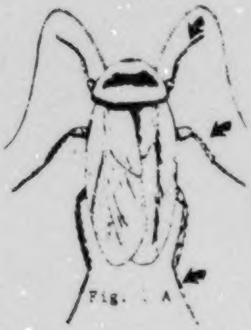

Fig. 1 A

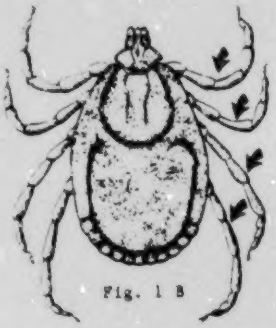

Fig. 1 B

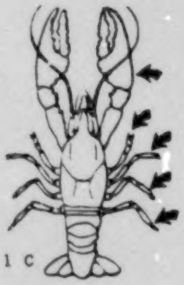

Fig. 1 C

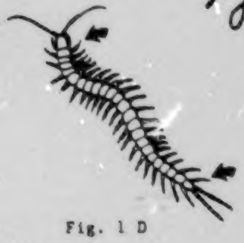

Fig. 1 D

2. Three pairs of walking legs (Fig. 2 A) 3

Four pairs of walking legs (Fig. 2 B) 25

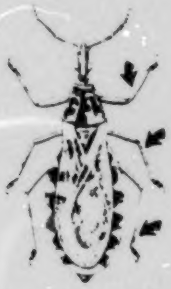

Fig. 2 A

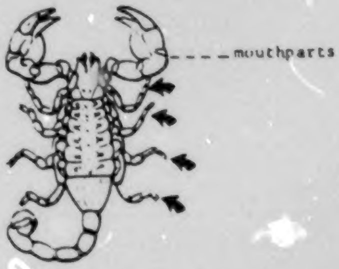

Fig. 2 B

3. Wings present, well developed (Fig. 3 A) 4

Wings absent or rudimentary (Fig. 3 B & C) 13

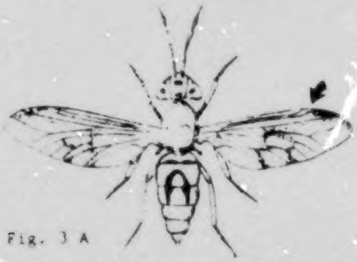

Fig. 3 A

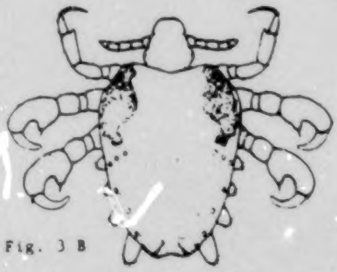

Fig. 3 B

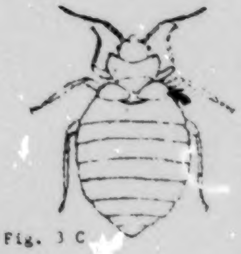

Fig. 3 C

4. With one pair of membranous wings (Fig. 4 A). ORDER DIPTERA 5

With two pairs of wings (Fig. 4 B & C) 6

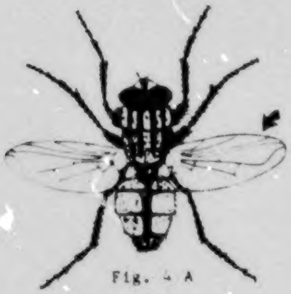

Fig. 4 A

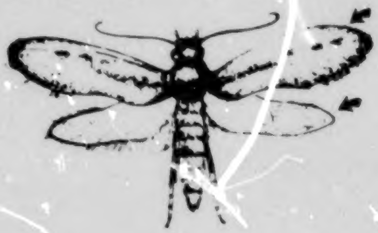

Fig. 4 B

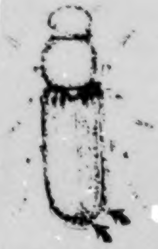

Fig. 4 C

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5. Wings with scales (Fig. 5 A). FAMILY CULICIDAE..MOSQUITO

Wings without scales (Fig. 5 B). DIPTERA OTHER THAN MOSQUITOES..................................FLY

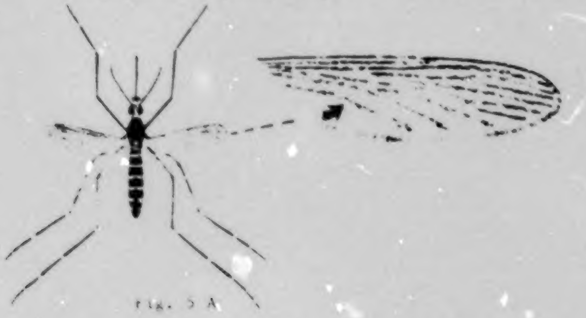

Fig. 5 A

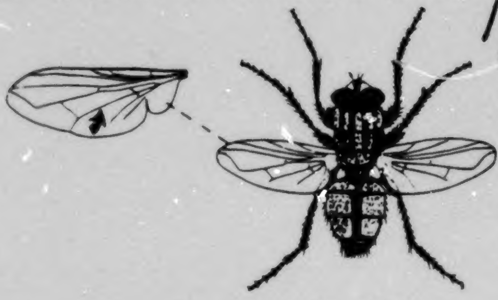

Fig. 5 B

6. Mouthparts adapted for sucking, with elongate proboscis (Fig. 6 A)..............................7

Mouthparts adapted for chewing, without elongate proboscis (Fig. 6 B)............................9

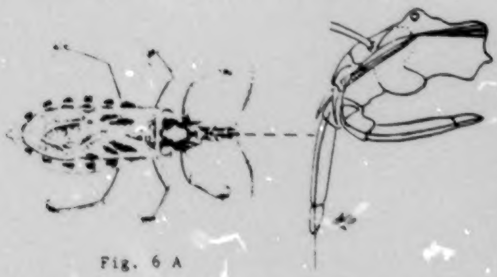

Fig. 6 A

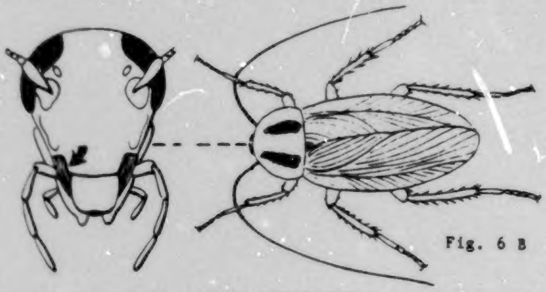

Fig. 6 B

7. Wings densely covered with scales; proboscis coiled (Fig. 7 A). ORDER LEPIDOPTERA..............
....MOTH OR BUTTERFLY

Wings not covered with scales; proboscis not coiled (Fig. 7 B)..................................8

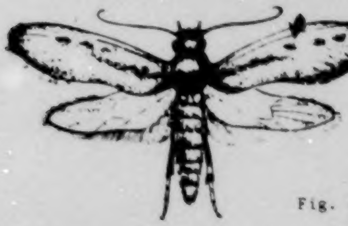

Fig. 7 A

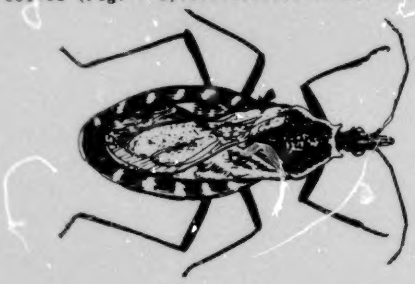

Fig. 7 B

8. Wing with fringe of long hair (Fig. 8 A). ORDER THYSANOPTERA..............................THRIPS

Wing without long hair (Fig. 8 B). ORDER HEMIPTERA..................................KISSING BUG

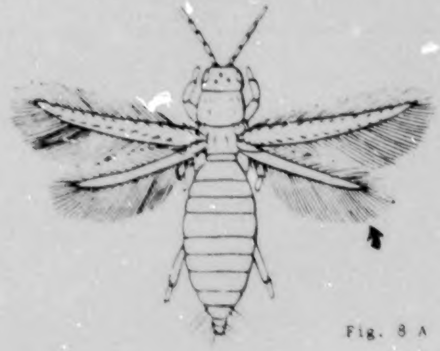

Fig. 8 A

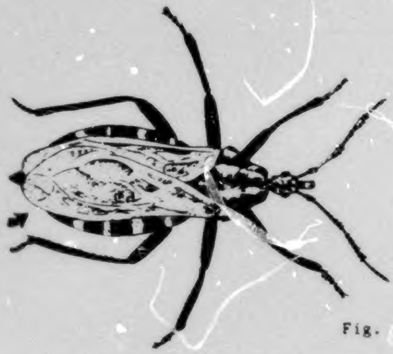

Fig. 8 B

9. Both pair of wings membranous and similar in structure (Fig. 9 A)..10

Front pair of wings shell-like or leathery, serving as covers for the second pair (Fig. 9 B)......11

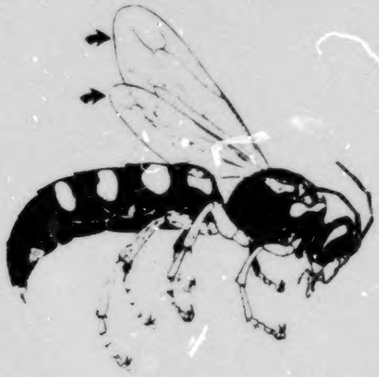

Fig. 9 A

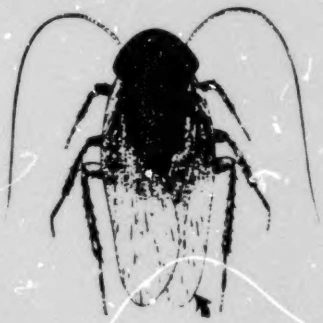

Fig. 9 B

10. Both pairs of wings similar in size (Fig. 10 A). **ORDER ISOPTERA**..............................TERMITE

Hind wing much smaller than front wing (Fig. 10 B). **ORDER HYMENOPTERA**.................................
....BEE, HORNET, WASP, YELLOW JACKET, OR ANT

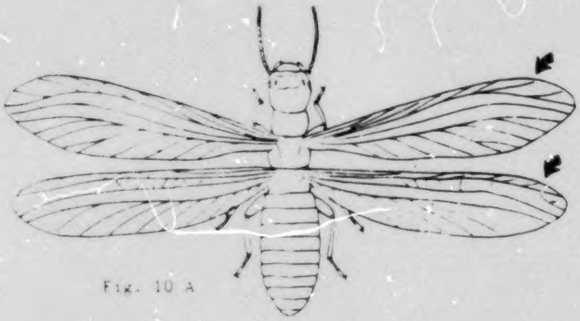

Fig. 10 A

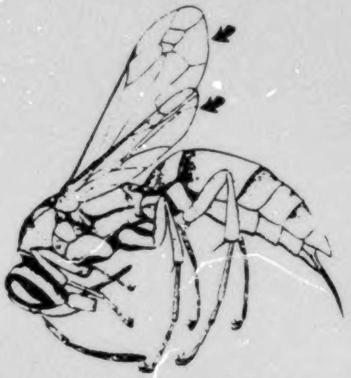

Fig. 10 B

11. Front wings horny or leathery, without distinct veins (Fig. 11 A)...................................12

Front wings leathery or paper-like, with distinct veins (Fig. 11 B). **ORDER DICTYOPTERA** ..COCKROACH

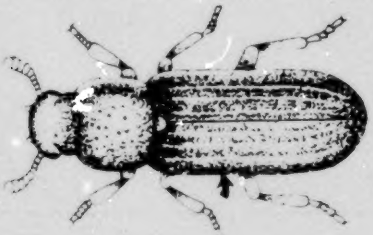

Fig. 11 A

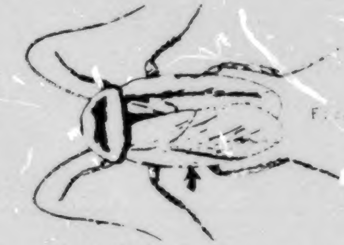

Fig. 11 B

12. Abdomen with prominent cerci, wings shorter than abdomen (Fig. 12 A). ORDER DERMAPTERA.......EARWIG

Abdomen without prominent cerci, wings covering abdomen (Fig. 12 B). ORDER COLEOPTERA........BEETLE

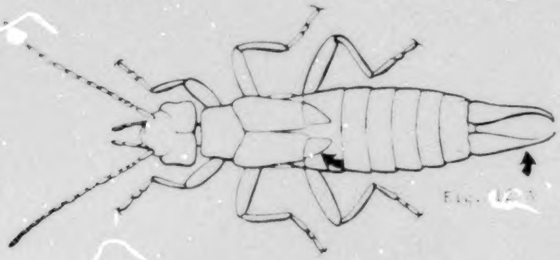

Fig. 12 A

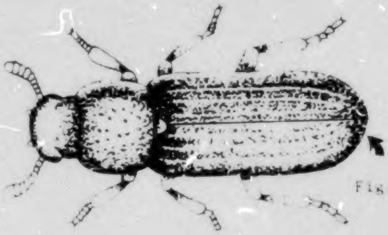

Fig. 12 B

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13. Mouthparts with jaws for chewing (Fig. 13 A)..14

Mouthparts with a long beak or stylets for sucking up food (Fig. 13 B)......................21

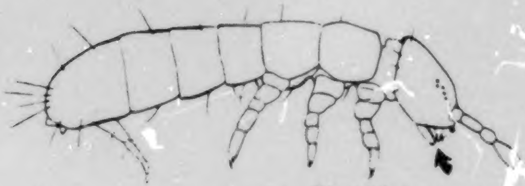


Fig. 13 A

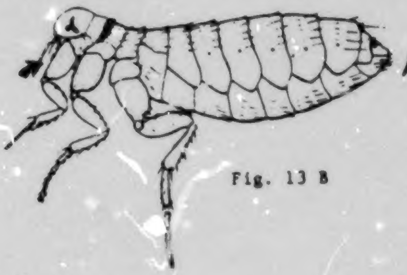


Fig. 13 B

14. With three long terminal tails (Fig. 14 A). ORDER THYSANURA..............SILVERFISH AND FIREBRAT

Without three long terminal tails (Fig. 14 B)...15

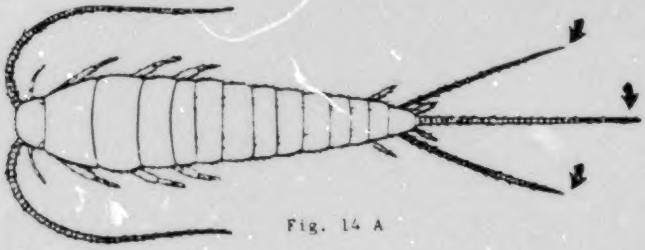


Fig. 14 A

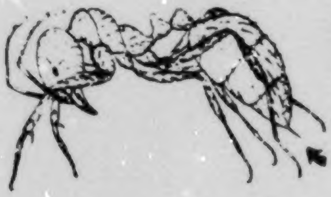


Fig. 14 B

15. Abdomen with prominent pair of cerci (Fig. 15 A). ORDER DERMAPTERA..........................EARWIG

Abdomen without prominent pair of cerci (Fig. 15 B)...16

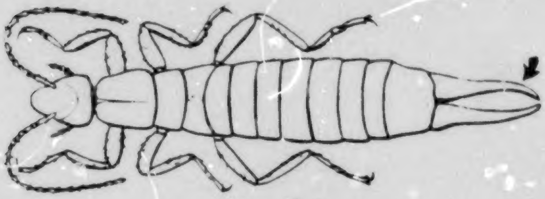


Fig. 15 A

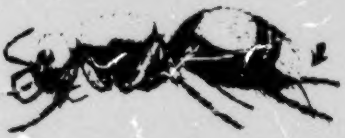


Fig. 15 B

16. With narrow waist (Fig. 16 A). ORDER HYMENOPTERA...ANT

Without narrow waist (Fig. 16 B)...17

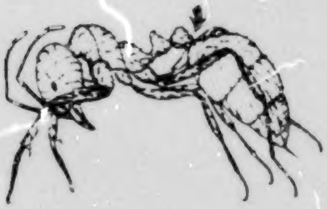


Fig. 16 A

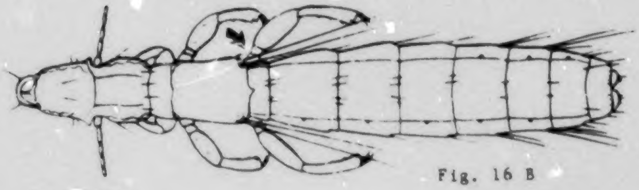


Fig. 16 B

CFA-083

17. Antenna with fewer than 8 segments (Fig. 17 A)...18

Antenna with more than 8 segments (Fig. 17 B)...19

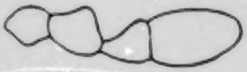


Fig. 17 A

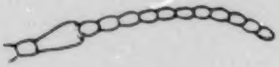


Fig. 17 B

18 Abdomen with 6 or fewer segments (Fig. 18 A). **ORDER COLLEMBOLA**.......................SPRINGTAIL

Abdomen with more than 6 segments (Fig. 18 B). **ORDER MALLOPHAGA**.......................CHEWING LOUSE

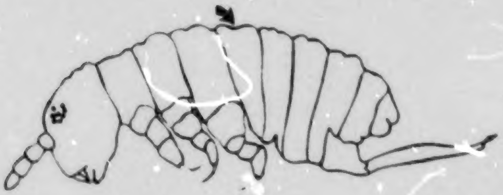


Fig. 18 A

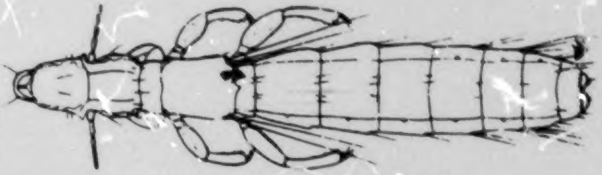


Fig. 18 B

19. Tarsus with 4-5 segments (Fig. 19 A)...20

Tarsus with 1-3 segments (Fig. 19 B). **ORDER PSOCOPTERA**.......................BOOK LOUSE OR PSOCID

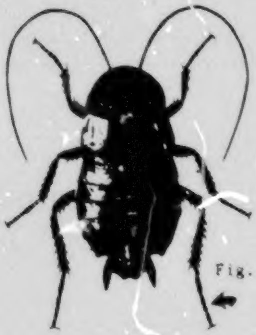


Fig. 19 A

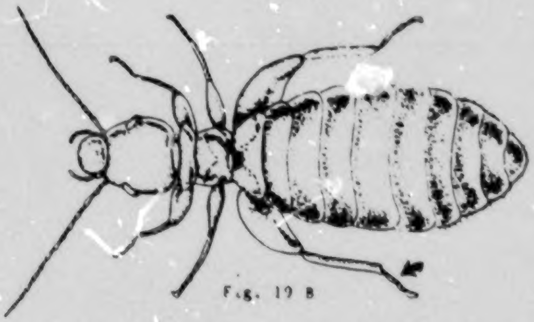


Fig. 19 B

20. Pronotum narrower than head, never covering head (Fig. 20 A). **ORDER ISOPTERA**...........TERMITE

Pronotum broader than head, often covering head (Fig. 20 B). **ORDER ORTHOPTERA**.......COCKROACH

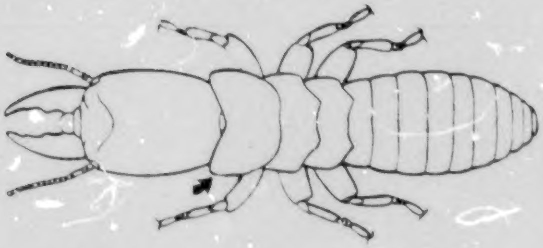


Fig. 20 A

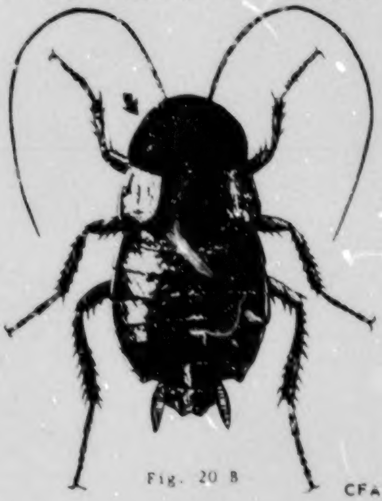


Fig. 20 B

CFA-084

21. Flattened laterally (Fig. 21 A). **ORDER SIPHONATERA**..FLEA

Flattened dorso-ventrally (Fig. 21 B)..22

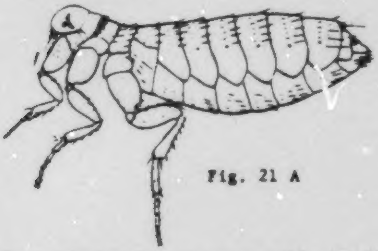


Fig. 21 A

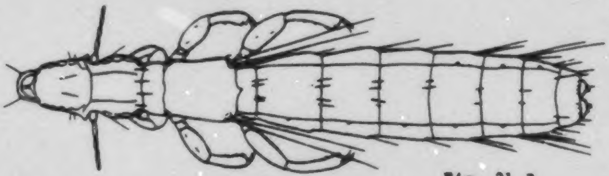


Fig. 21 B

22. Foot terminating in protrusible bladder (Fig. 22 A). **ORDER THYSANOPTERA**.................THRIPS

Foot not terminating in protrusible bladder (Fig. 22 B)..23

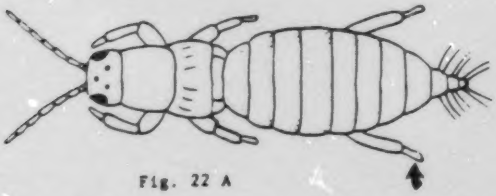


Fig. 22 A

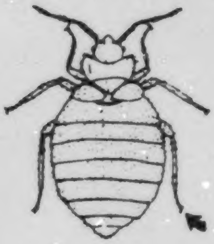


Fig. 22 B

23. Beak jointed (Fig. 23 A). **ORDER HEMIPTERA**..BEDBUG

Beak not jointed (Fig. 23 B)...24

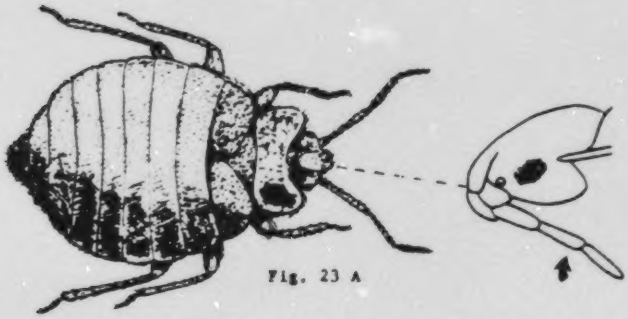


Fig. 23 A

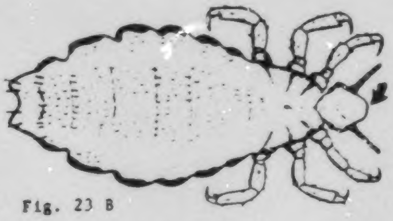


Fig. 23 B

24. Mouthparts retracted into head (Fig. 24 A). **ORDER ANOPLURA**.........................SUCKING LOUSE

Mouthparts not retracted into head (Fig. 24 B). **ORDER DIPTERA**.................KED OR LOUSE FLY

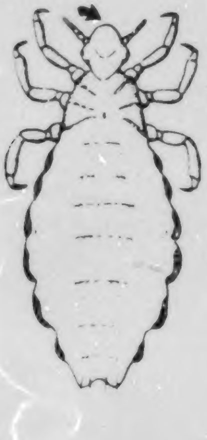


Fig. 24 A

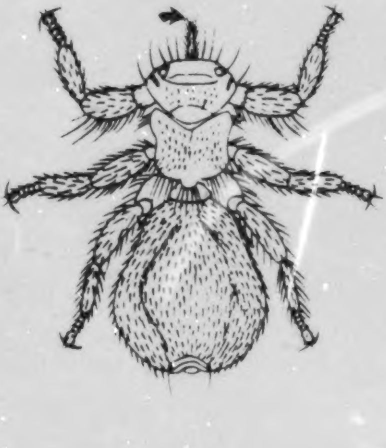


Fig. 24 B

CFA-085

25. Abdomen well-developed (Fig. 25 A). CLASS ARACHNIDA....................................26

Abdomen peg-like (Fig. 25 B). CLASS PYCNOGONIDA....................................SEA SPIDER

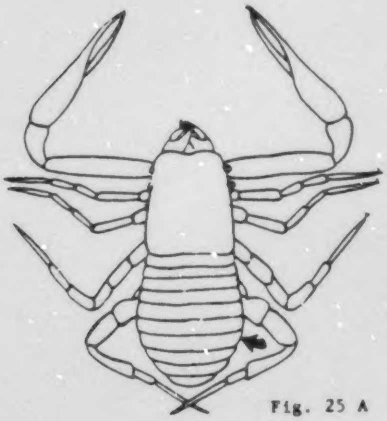


Fig. 25 A

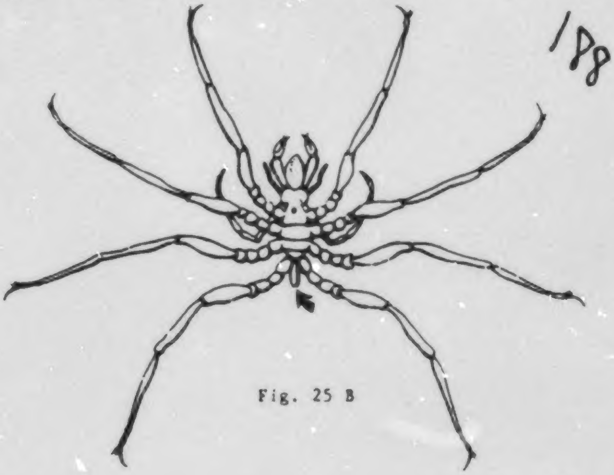


Fig. 25 B

26. Abdomen distinctly segmented (Fig. 26 A)....................................27

Abdomen not distinctly segmented (Fig. 26 B)....................................31

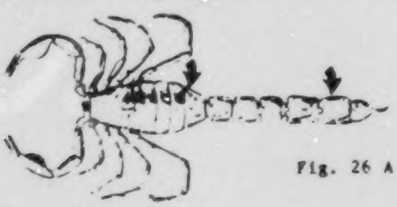


Fig. 26 A

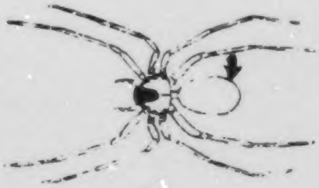


Fig. 26 B

27. Abdomen lengthened to form a long tail (Fig. 27 A)....................................28

Abdomen not lengthened to form a long tail (Fig. 27 B)....................................29

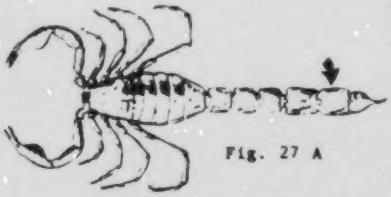


Fig. 27 A

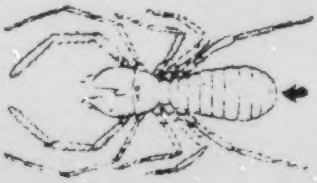


Fig. 27 B

28. Tail with stinger (Fig. 28 A). ORDER SCORPIONIDA....................................SCORPION

Tail without stinger (Fig. 28 B). ORDER PEDIPALPIDA....................................WHIP SCORPION

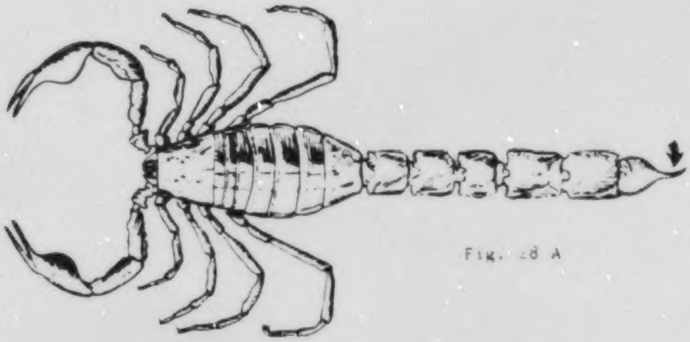


Fig. 28 A

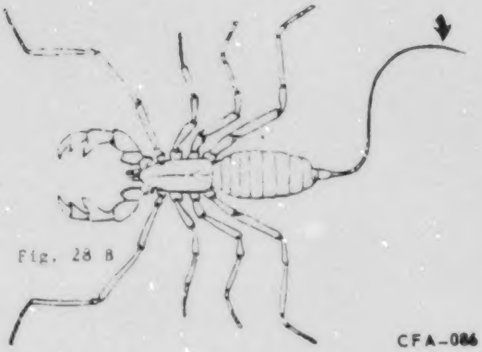


Fig. 28 B

CFA-086

29. With large pincer-like claws (Fig. 29 A). ORDER PSEUDOSCORPIONIDA...............PSEUDOSCORPION

Without large pincer-like claws (Fig. 29 B)..30

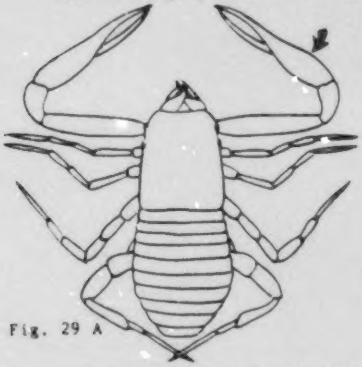


Fig. 29 A

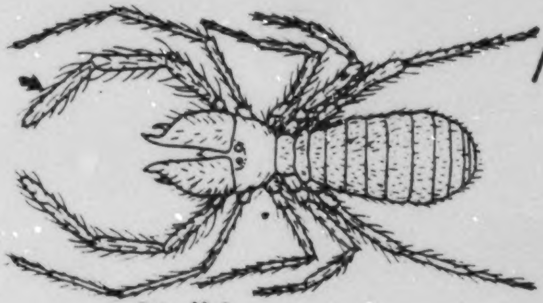


Fig. 29 B

30. Legs not longer than body (Fig. 30 A). ORDER SOLPUGIDA..............................SUN SPIDER

Legs much longer than body (Fig. 30 B). ORDER PHALANGIDA.................DADDY LONG-LEG SPIDER

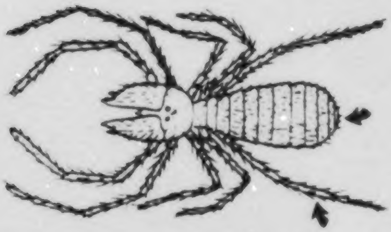


Fig. 30 A

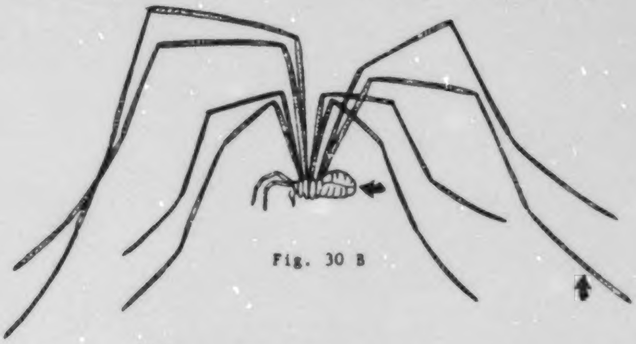


Fig. 30 B

31. Abdomen constricted to form a narrow waist (Fig. 31 A). ORDER ARANEIDA.................SPIDER

Abdomen not constricted (Fig. 31 B)..32

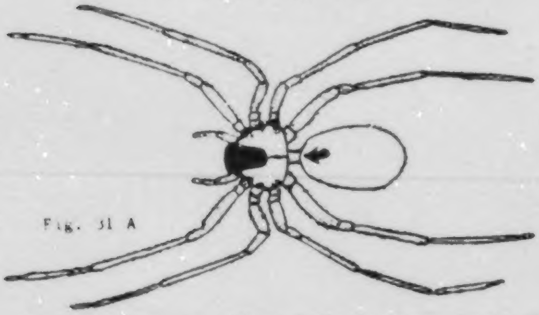


Fig. 31 A

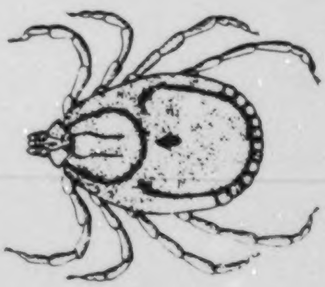


Fig. 31 B

32. Body with long hair; Haller's organ absent (Fig. 32 A). ORDER ACARINA.....................MITE

Body without hair or short hair; Haller's organ present (Fig. 32 B). ORDER ACARINA........TICK

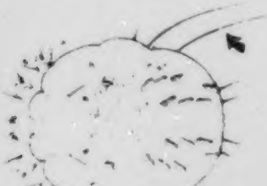
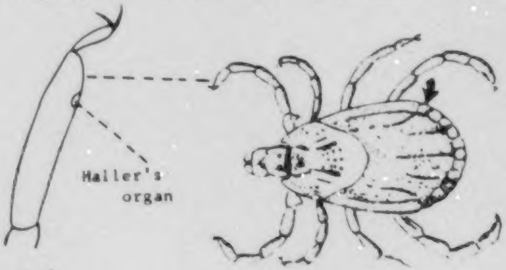


Fig. 32 A



33. Five to 7 pairs of walking legs (Fig. 33 A). CLASS CRUSTACEA....................................34

More than 14 pairs of walking legs (Fig. 33 B)..36

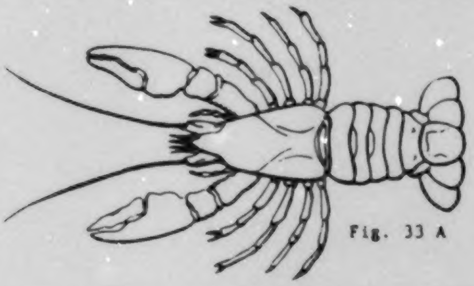


Fig. 33 A

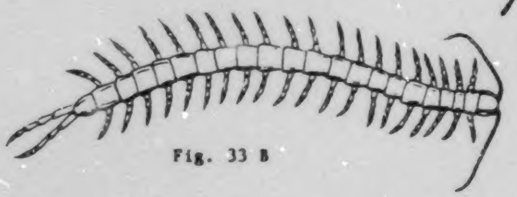


Fig. 33 B

34. Abdomen without appendages (Fig. 34 A). ORDER COPEPODA....................................COPEPOD

Abdomen with appendages (Fig. 34 B)..35

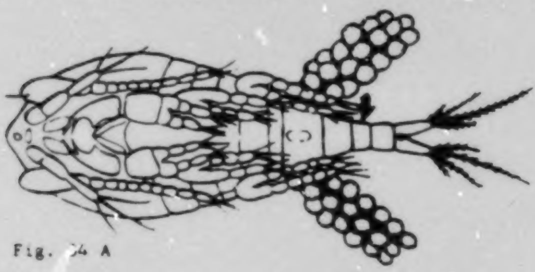


Fig. 34 A

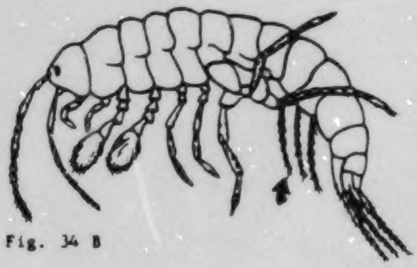


Fig. 34 B

35. Thorax covered with a fused plate; eyes, when present, on movable stalks (Fig. 35 A & B)...........
ORDER DECAPODA...LOBSTER, CRAB, CRAYFISH, SHRIMP, ETC.

Thorax not covered with a fused plate; eyes, when present, not on movable stalks (Fig. 35 C & D)...
ORDER ISOPODA...SOWBUG, PILLBUG

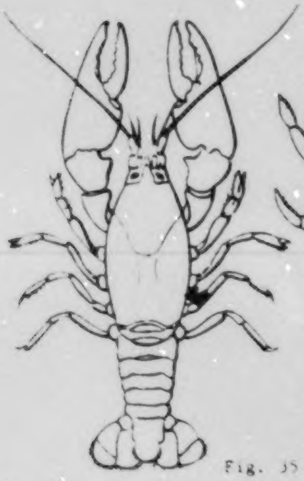


Fig. 35 A

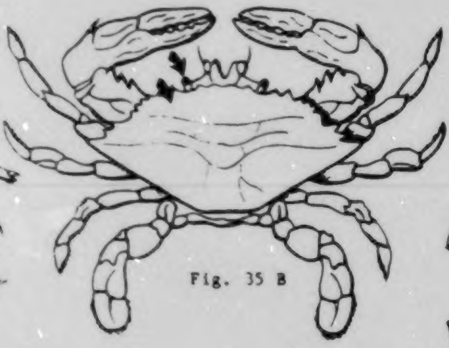


Fig. 35 B

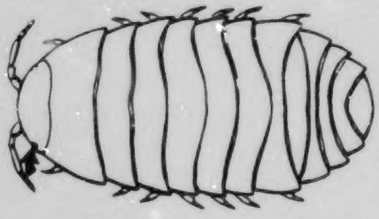


Fig. 35 C

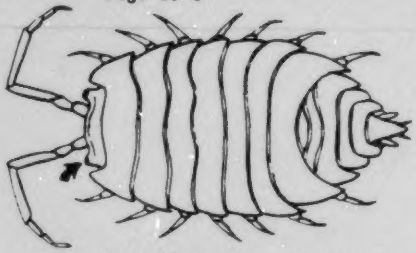


Fig. 35 D

36. One pair of legs per body segment (Fig. 36 A). CLASS CHILOPODA...........................CENTIPEDE

Two pairs of legs per body segment (Fig. 36 B). CLASS DIPLOPODA..........................MILLIPEDE

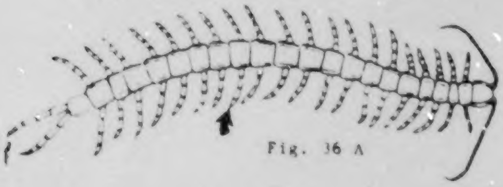


Fig. 36 A

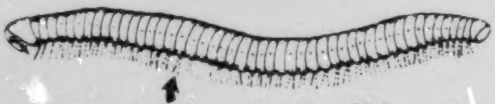


Fig. 36 B

Answers For Exercises

CHAPTER 1

References:

200 - 1. The arrangement of living things into groups having similar characteristics.
200 - 2. Systematic biology.
200 - 3. Standardized; universally.

201 - 1. The binominal system means applying two names to an organism.
201 - 2. Pulex.
201 - 3. Domestica.
201 - 4. Scientific name.

202 - 1. Kingdom.
202 - 2. Class.
202 - 3. Genus.
202 - 4. Phyla.
202 - 5. Phyla; Orders.
202 - 6. Structure.

203 - 1. a. Animal.
  b. Phylum.
203 - 2. a. Capable of motion.
  b. An exoskeleton.

204 - 1. False.
204 - 2. Arthropoda.
204 - 3. Insecta and Arachnida.
204 - 4. Crustacea.
204 - 5. a. 2.
  b. 3.
  c. 5.
  d. 1.
  e. 4.

205 - 1. Three.
205 - 2. Exoskeleton.
205 - 3. Respiration; abdomen.
205 - 4. Flies; small knobs; balancer.
205 - 5. Wing; thorax.
205 - 6. a. I.
  b. C.
  c. I.
  d. I.
205 - 7. Metamorphosis.
205 - 8. Incomplete (gradual) metamorphosis.
205 - 9. Complete metamorphosis.
205 - 10 Without metamorphosis.
205 - 11. Molt.

206 - 1. b.
206 - 2. n.
206 - 3 h.
206 - 4. a.
206 - 5. k.
206 - 6. e.
206 - 7. o.
206 - 8. j.
206 - 9. f.
206 - 10. c.
206 - 11. m.
206 - 12. i.
206 - 13. l.
206 - 14. d.
206 - 15. g.

207 - 1. c.
207 - 2. a.
207 - 3. b.

208 - 1. e.
208 - 2. c.
208 - 3. b.
208 - 4. a.
208 - 5. d.
208 - 6. a. Oviparous.
  b. Parthenogenesis.
  c. Chitin.
  d. Intersegmental membranes.
  e. Skeletal system.
  f. "Open."

209 - 1. Smell.
209 - 2. Touch; hearing.
209 - 3. False.
209 - 4. False.
209 - 5. Smell.
209 - 6. Depositing the eggs.
209 - 7. Compound.
209 - 8. Fly.
209 - 9. Stimuli.

CHAPTER 2

210 - 1. a. Original/basic survey.
  b. Routine survey.
  c. Operational survey.
210 - 2. a. To provide the basis for determining whether or not management programs should be implemented.
  b. To provide the basis for determining the type of management program to be implemented.
  c. To monitor conditions that may possibly enhance pest problems.
  d. To evaluate pest management programs.
210 - 3. Probing.
210 - 4. Skimming.
210 - 5. Trapping.
210 - 6. Dipping, biting (and) landing count.

211 - 1. (a) Surveillance and (b) identification.
211 - 2. Live collections must be conducted when specimens are to be used for research.

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211 - 3. a. (1) Trapping.
- (a) Light traps.
- (b) Cage traps.

(2) Biting and resting.
- (a) Aspirators.

b. (1) Cloth drags.
- (a) Flannel cloth drag.

(2) Picking.
- (a) Tweezers.

c. (1) Trapping.
- (a) Cage traps.

d. (1) Dipping.
- (a) Dipper.

(2) Skimming.
- (a) Dipper.

e. (1) Combing.
- (a) Comb.

(2) Brushing.
- (a) Brush.

(3) Swirling.
- (a) Swirling jar.

(4) Picking.
- (a) Tweezers.

212 - 1. Pictorial; dichotomous.
212 - 2. Dichotomous.
212 - 3. Pictorial.
212 - 4. a. (1) Dictyoptera.
(2) Cockroach.
(3) 1, 2, 3, 4, 6, 9 (and) 11.
b. (1) Acarina.
(2) Tick.
(3) 1, 2, 25, 26, 31 (and) 32.

213 - 1. Adjust the width of the eyepiece adapter.
213 - 2. To adjust the magnification.
213 - 3. Properly illuminate the specimen.
213 - 4. Right eye.
213 - 5. Clean with a cotton swab that has been moistened with a soap detergent solution and dry with a cotton swab.
213 - 6. False.

214 - 1. Allow interested persons to become familiar with pests common to the area.
214 - 2. Dry preservation.
214 - 3. 2 percent caustic potash; synthetic detergent.
214 - 4. Cut off the abdomen at the base, lay it on a flat surface, and squeeze the fluid out by rolling a small round object from abdomen tip toward the cut off portion.
214 - 5. Camel's-hair brush.
214 - 6. Ethyl acetate, benzene, and ether.
214 - 7. Direct, staging, carding, and pointing.
214 - 8. Scientific name of specimen, the scientist who described the specimen, and the date originally described.
214 - 9. Paradichlorobenzene; naphthalene.

215 - 1. Soft-bodied.
215 - 2. Ethyl alcohol, Pampel's fluid (and) chloral hydrate.
215 - 3. Spirit-preserved specimens should be stored in a cool, dark area and away from all sources of heat.
215 - 4. Smearing.

216 - 1. Remove air bubbles.
216 - 2. 4; 5.
216 - 3. Back and forth motion.
216 - 4. a. Determine the number of liquid ounces required to fill the container.
b. Convert the ounces into cubic centimeters.
c. Divide the total cubic centimeters by 3.

217 - 1. 10 percent caustic potash; 12 hours.
217 - 2. Lighten.
217 - 3. Acetic acid.
217 - 4. Acid fuchsin.
217 - 5. Water.
217 - 6. Dehydrate.
217 - 7. Caustic potash.

218 - 1. (1) b.
(2) a.
(3) d.
(4) c.
218 - 2. Medical service.
218 - 3. Major command.

219 - 1. After-the-fact situation or predicting pest problems based upon previous records.
219 - 2. County Health Office.
219 - 3. County Extension Office and the County Health Office.
219 - 4. Average rainfall annually, average temperatures, average wind speed, and average wind direction.
219 - 5. Pest Control Historical Report.
219 - 6. Pest Summary Report.
219 - 7. Original/basic survey.

220 - 1. b, d.
220 - 2. a, b, c, d, f.
220 - 3. c, f.
220 - 4. e, f.
220 - 5. a.
220 - 6. a, c.

221 - 1. c.
221 - 2. e.
221 - 3. h.
221 - 4. f.
221 - 5. i.
221 - 6. g.
221 - 7. b.
221 - 8. d.
221 - 9. a.
221 - 10. j.
221 - 11. k.

222 - 1. Natural.
222 - 2. Applied - preventive.
222 - 3. Applied - corrective - preventive.
222 - 4. Applied - corrective.
222 - 5. Applied - preventive.

223 - 1. Legal; biological.
223 - 2. Chemical.
223 - 3. Sanitation.
223 - 4. a. 2.
b. 6.
c. 5.
d. 1.
e. 2.
f. 4.
g. 3.
h. 3.
i. 1.
j. 5.
k. 4.
l. 4.

224 - 1. Misting.
224 - 2. Dusting.
224 - 3. Fumigation.
224 - 4. Aerosoling.
224 - 5. Fumigation.
224 - 6. Granulation.
224 - 7. Baiting.

225 - 1. b.
225 - 2. a.
225 - 3. a.
225 - 4. b.

225 - 5. b.
225 - 6. a.
225 - 7. b.
225 - 8. a.
225 - 9. a.
225 - 10. a.
225 - 11. a.
225 - 12. a.
225 - 13. a.
225 - 14. a.
225 - 15. b.

226 - 1. e.
226 - 2. c.
226 - 3. f.
226 - 4. d.
226 - 5. a.
226 - 6. b.

227 - 1. a. Pesticide resistance.
b. Effects and effectiveness of pesticides.
c. Effects and effectiveness of techniques.
d. Effects and effectiveness of equipment.
227 - 2. a. Insure that pesticides are prepared and applied accurately; collect and ship live specimens.
227 - 2. b. Use, monitor, and annotate the effects and effectiveness.
c. Same as b.
d. Same as b and c.

228 - 1. All personnel engaged in direct field supervision of pest management operations or those who operate independently of direct supervision.
228 - 2. Two years.
228 - 3. To identify individuals who have proved that they are competent in handling pesticides in accordance with Federal laws and to insure that they are aware of, and knowledgeable of, current policies relating to all phases of pest management.
228 - 4. Civil engineering.
228 - 5. Request certification through proper channels to the designated certifying official.
228 - 6. a. Category of certification requested.
b. Name of individual.
c. Military rank or civilian grade.
d. Social security number.
e. Training accomplishments within the career field.
f. Length of time performed in the career field (experience).

229 - 1. Require repetitive treatment.
229 - 2. Resistant.
229 - 3. Each time pesticides are applied.
229 - 4. a. Provides a complete record of treatment.
b. Identifies the individual who performed the treatment.
c. Serves as proof of treatment.
d. Eliminates the need of producing and reproducing local forms or logs.
229 - 5. At any time after 15 November 1979.

230 - 1. Facilities that are constructed completely or partly of wood.
230 - 2. They must be inspected annually; however, they should be inspected semiannually.
230 - 3. To record inspections, provide information pertaining to the building conditions, and to record actions taken.
230 - 4. After the building has been disposed of or if the installation is inactivated and dropped from real property accounts.
230 - 5. Date Inspected - 14 January 1977.
Building Number - 302.
Installation - Mitchell AFB.
Type Building - "Permanent" block should show an "X."
Inspector - Self Alone.
Block I, Other (Specify) - "Deteriorated attic vent screens."
Block II, Other (Specify) - "Termites in rafters."
Block III - An "X" should appear in block beside "Nonsubterranean."
Block V - An "X" should appear in block beside "Superficial."
Block VI - Other (Specify) - "Replace screens over attic vents; inject rafter with pentachlorophenol."
Block VII - The Yes block should have an "X" in the Wood Injection for Dry-wood Termite space. To the right of that in Chemical Used space the word "pentachlorophenol" should appear.
Block VIII - Labor - $227.00
Material - $73.00
Other - $36.00
Total - $330.00
Block IX - Date - 17 January 1977.
Title of individual - Section Supervisor.
Signature - Name of Self Alone signed.

231 - 1. Daily; AFR 91-21.
231 - 2. To create a Pest File.
231 - 3. Daily pest management activities.
231 - 4. AFR 91-21, AFM 300-4 (and) AFM 84-200.
231 - 5. AFM 300-4.
231 - 6. Data element code AVDJO should be entered in columns 1 through 5 on lines 1 and 7.
Data element code AVAT should be entered in columns 6 through 9 on line 1 only.
A "1" should be entered in column 17 on line 1 for Area Treated.
An "A" and a "C" should be entered in columns 18 and 19, respectively, on line 1 for Unit of Measure.
A "2" should be entered in column 20 on lines 1 and 7 for Building Terrain.
Data element code SNOP20 should be entered in columns 21 through 26 on line 1 only.
The abbreviation EMUL should be entered in columns 27 through 30 on line 1 for Pesticide Form.
An "8" should be entered in column 36 on line 1 for Pesticide Quantity.
An "L" and a "B" should be entered in columns 37 and 38, respectively, on line 1 for Unit of Measure.
An "S" should be entered in column 39 on line 1 for Supply Source.
A "1" and a "2" should be entered in columns 44 and 45, respectively, on line 1 for Man-Hours Labor.
A "3" should be entered in column 51 on line 7 for Man-Hours Survey.
A "1" and a "0" should be entered in columns 78 and 79, respectively, on lines 1 and 7 for Month.
A "1" should be entered in column 80 on line 1, and a "2" should be entered in column 80 on line 7 for Card Code.

CHAPTER 3

232 - 1. a. To provide laws pertaining to the certification of the usefulness of chemicals employed in agriculture.
b. To provide specified requirements for safety precautions in handling and applying agricultural chemicals.
c. To provide specified requirements for registering agricultural chemicals every 5 years.
232 - 2. Keep Out of Reach of Children.
232 - 3. Congress.
232 - 4. Nematodes, plant growth regulators, desiccants (and) defoliants.

233 - 1. Amendment; FIFRA.
233 - 2. To extend Federal registration and regulation to all pesticides.
233 - 3. You should have placed an X beside c, d, and f.

234 - 1. It was created because of continuing pressure to limit the use of pesticides. It combines all activities of the Federal Government concerned with pesticides and their effect on the environment into a single agency.
234 - 2. You should have placed an X beside a, c, and d.
234 - 3. Department of Agriculture, Department of Interior, and Department of Health, Education, and Welfare.

235 - 1. US Department of Labor.
235 - 2. To insure that all employees have safe and healthy working conditions.
235 - 3. a. Develop and publish occupational safety standards.
b. Inspect work areas to insure that standards are met.
c. Issue citations for noncompliance with its regulations.
d. Maintain education, training, and information programs to promote safe practices.

236 - 1. US Department of Health, Education, and Welfare.
236 - 2. Formulate improved occupational and health standards.
236 - 3. Testing and approving many items of personal safety protective equipment.

237 - 1. As long as the State and local requirements are more stringent.
237 - 2. The more stringent requirements, whether they be Federal, State, or local requirements.
237 - 3. To establish minimum Federal requirements for environmental protection.

238 - 1. The pesticide label serves the same purpose as an Air Force regulation.
238 - 2. The safe storage, mixing, uses, and application of that specific pesticide.
238 - 3. Highly toxic pesticides.
238 - 4. a. 6
b. 3
c. 11
d. 8
e. 1
f. 12
g. 5
h. 9
i. 2
j. 10
k. 4
l. 7

239 - 1. It should be located in an area separate from other activities.
239 - 2. Paved or lined with impervious material.
239 - 3. 7½ feet.
239 - 4. You should have placed an X beside b, d, f, i, j, l, and m.
239 - 5. EPA and OSHA Standards, NEC Articles, and Air Force publications.
239 - 6. Pesticides should be separated into like substances and stored in separate areas because they may possibly react with each other, which could present potential explosion and fire hazards.
239 - 7. Exhaust ventilation system with hood.
239 - 8. Six.
239 - 9. Pesticide mixing area.

240 - 1. On the outer surface of each door.
240 - 2. They must be segregated and stored separately according to the method of disposal.
240 - 3. Prior.
240 - 4. Sound.
240 - 5. Easy; easy.
240 - 6. Appropriate fire extinguishers.

241 - 1. Ventilated; lighted.
241 - 2. First aid.
241 - 3. Amount.
241 - 4. Eye; face.
241 - 5. Contaminated; toxic.

242 - 1. Locked.
242 - 2. Children; people.
242 - 3. Repair.
242 - 4. Entomology.
242 - 5. Label.
242 - 6. Storage; locked.

243 - 1. Spills.
243 - 2. Calibrated.
243 - 3. Drifts.
243 - 4. Vehicular; pedestrian.
243 - 5. Plan ahead; action.
243 - 6. No smoking, eating, or drinking while handling pesticides.
243 - 7. Daily Bulletin and/or base newspaper.
243 - 8. Be escorted by an escort vehicle.
243 - 9. Pesticides that are to be used, signs and symptoms that are characteristic of the pesticide, and the precautions that can be taken.

244 - 1. Landfill: standards.
244 - 2. Excess.
244 - 3. 19-1.
244 - 4. Rinsed; three times.
244 - 5. Stored.

245 - 1. Tool.
245 - 2. When the pesticide is very toxic or when the quantity is significant.
245 - 3. To provide additional security measures, the capability of detecting deterioration of containers, and an additional means of insurency that pesticides are properly stored.
245 - 4. No. They do not know how to apply pesticides nor the proper way to store them.
245 - 5. At least once a month, but more often if desired.
245 - 6. You must record all pesticides that have been received and withdrawn from the time of the last inventory until the present inventory.

246 - 1. You.
246 - 2. You would be guilty of disobeying a direct order.
246 - 3. AFR 127-101.
246 - 4. Major command.
246 - 5. Base Civil Engineer.
246 - 6. Substitute; supplement.
246 - 7. 91-21; Director of Base Medical Services.

247 - 1. They are not to be worn to dining facilities, snack bars, and base exchange facilities except while performing actual entomology duties.
247 - 2. Washing machines and dryers.
247 - 3. You will wear a rainsuit.
247 - 4. Rainsuit.
247 - 5. Apron.
247 - 6. Pubic.
247 - 7. With the tops beneath the legs of the coveralls or rainsuit.
247 - 8. During all phases of pesticide handling.
247 - 9. Liquid.
247 - 10. Goggles or faceshields.
247 - 11. Earplugs.
247 - 12. NIOSH; MESA.
247 - 13. Odors; breathe.
247 - 14. Soap; water.
247 - 15. Vegetable; drying; cracking.

248 - 1. Anticoagulants.
248 - 2. Pyrethrum.
248 - 3. Organophosphates; carbamates.
248 - 4. Methyl bromide.

249 - 1. Pyrethrum.
249 - 2. Hydrogen phosphide.
249 - 3. Carbamate.
249 - 4. A sign of pesticide poisioning can be noticed by someone else, whereas a symptom of pesticide poisioning can only be noticed by you.
249 - 5. Sweating, salivation, vomiting, diarrhea.
249 - 6. Corrected more easily
249 - 7. Petroleums; fumigants.
249 - 8. Anticoagulant.

250 - 1. e.
250 - 2. c.
250 - 3. a.
250 - 4. b.
250 - 5. d.
250 - 6. Ignorance; negligence.
250 - 7. Store all pesticides in a secure area, observe the no smoking, eating, or drinking rule.

251 - 1. a. Don air-supplied respirator and remove victim to fresh air.
  b. Loosen tight clothing.
  c. Treat the victim for shock.
  d. Determine type of pesticide involved, if possible.
  e. Obtain medical assistance as rapidly as possible.
251 - 2. a. Don gloves and remove the victim from contaminated area.
  b. Decontaminate the victim by drenching the entire body.
  c. Treat the victim for shock.
  d. Call for medical assistance and provide all information possible at the time.
  e. Try to determine the type of pesticide responsible for the poisoning and remain by the victim.
251 - 3. a. Administer back pressure - armlift artificial respiration.
  b. Obtain medical assistance as rapidly as possible.
  c. Treat the victim for shock and monitor the victim's condition at all times.
251 - 4. Remove the pesticide as quickly as possible.
251 - 5. Because the severity is not actually known and to alert medical staff for possible side effects.
251 - 6. The statement of practical treatment found on the pesticide label.
251 - 7. To plan ahead by anticipating possibilities of pesticide poisoning and establishing action to be taken in the event of pesticide poisoning.
251 - 8. (a) To keep the victim alive.
  (b) Obtain medical assistance.
251 - 9. Professional medical assistance.
251 - 10. On your own common knowledge of first aid and the circumstances involved at the time.
251 - 11. Circumstances.
251 - 12. Back pressure - armlift.

252 - 1. Pesticide.
252 - 2. Unconscious.
252 - 3. If it has been determined that the victim has swallowed a noncorrossive substance and the victim is conscious and not convulsive.
252 - 4. If the victim has swallowed petroleum products or if the victim is unconscious or convulsive.
252 - 5. Temporary; professional medical.
252 - 6. Speed.
252 - 7. Milk and milk of magnesia.
252 - 8. Atropine.
252 - 9. Four tablespoons of crumbled black toast, 2 tablespoons of strong tea solution, and 2 tablespoons of milk of magnesia.
252 - 10. Organochlorines, phenoxys, hydrogen cyanide, pentachlorophenol, nicotine sulfate (and) sodium fluoroacetate.
252 - 11. 2-PAM
252 - 12. BAL.
252 - 13. Anticoagulant.
252 - 14. To clot the blood in humans.

STOP - 1. **MATCH ANSWER SHEET TO THIS EXERCISE NUMBER.**
2. USE NUMBER 2 PENCIL ONLY.

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EXTENSION COURSE INSTITUTE
VOLUME REVIEW EXERCISE
56650 02 21
INTRODUCTION TO PEST MANAGEMENT

Carefully read the following:

DO's:

1. Check the "course," "volume," and "form" numbers from the answer sheet address tab against the "VRE answer sheet identification number" in the righthand column of the shipping list. If numbers do not match, take action to return the answer sheet and the shipping list to ECI immediately with a note of explanation.
2. Note that item numbers on answer sheet are sequential in each column.
3. Use a medium sharp #2 black lead pencil for marking answer sheet.
4. Write the correct answer in the margin at the left of the item. (When you review for the course examination, you can cover your answers with a strip of paper and then check your review answers against your original choices.) After you are sure of your answers, transfer them to the answer sheet. If you have to change an answer on the answer sheet, be sure that the erasure is complete. Use a clean eraser. But try to avoid any erasure on on the answer sheet if at all possible.
5. Take action to return entire answer sheet to ECI.
6. Keep Volume Review Exercise booklet for review and reference.
7. If mandatorily enrolled student, process questions or comments through your unit trainer or OJT supervisor. If voluntarily enrolled student, send questions or comments to ECI on ECI Form 17.

DON'Ts:

1. Don't use answer sheets other than one furnished specifically for each review exercise.
2. Don't mark on the answer sheet except to fill in marking blocks. Double marks or excessive markings which overflow marking blocks will register as errors.
3. Don't fold, spindle, staple, tape, or mutilate the answer sheet.
4. Don't use ink or any marking other than a #2 black lead pencil.

NOTE: NUMBERED LEARNING OBJECTIVE REFERENCES ARE USED ON THE VOLUME REVIEW EXERCISE. In parenthesis after each item number on the VRE is the Learning Objective Number where the answer to that item can be located. When answering the items on the VRE, refer to the Learning Objectives indicated by these Numbers. The VRE results will be sent to you on a postcard which will list the actual VRE items you missed. Go to the VRE booklet and locate the Learning Objective Numbers for the items missed. Go to the text and carefully review the areas covered by these references. Review the entire VRE again before you take the closed-book Course Examination.

MULTIPLE CHOICE

1. (200) Systematic biology classifies living things into

a. groups having similar characteristics.
b. animal or vegetable groups.
c. land or water groups.
d. airborne or land groups.

2. (201) What is meant by the binomial system of nomenclature?

a. Using two classification systems.
b. Classifying plants and animals separately.
c. Applying two names to an organism.
d. Classifying plants and animals by a name and a number.

3. (202) What are the major divisions of the animal kingdom?

a. Phyla.
b. Classes.
c. Genera.
d. Species.

4. (202) Which of the following terms represents the greatest degree of nomenclature breakdown in the animal kingdom?

a. Phyla.
b. Class.
c. Order.
d. Family.

5. (203) Man and insects are classified in the same

a. phylum.
b. kingdom.
c. class.
d. genus.

6. (203) What is meant by exoskeleton?

a. No skeleton.
b. Skeleton on the inside.
c. Skeleton on the outside.
d. No bones in the skeleton.

7. (204) What class includes scorpions?

a. Diplopoda.
b. Chilopoda.
c. Insecta.
d. Arachnida.

8. (204) Which of the following classes are of main concern to us?

a. Insecta and Arachnida.
b. Insecta and Diplopoda.
c. Arachnida and Chilopoda.
d. Arachnida and Diplopoda.

9 (205) The purpose of intersegmental membranes in insects is to

a. protect internal organs.
b. allow movement between body parts.
c. provide a point for attachment of legs.
d. allow the insect to grow.

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10. (205) The three main body regions of an insect are the

a. prothorax, mesothorax, and metathorax.
b. head, thorax, and abdomen.
c. proboscis, thorax, and legs.
d. exoskeleton, head, and thorax.

11. (026) Sucking lice belong to which of the following orders?

a. Coleoptera.
b. Dermaptera.
c. Diptera.
d. Anoplura.

12. (206) The order of insects that is most beneficial to man is

a. Homoptera.
b. Isoptera.
c. Hymenoptera.
d. Mallophaga.

13. (207) Spiders are considered beneficial to man because

a. they are generally harmless and destroy other pests.
b. their web is very useful.
c. they are harmless and aid in food production.
d. their bite builds immunity to other poisons.

14. (207) To which class do spiders and scorpions belong?

a. Diplopoda.
b. Arachnida.
c. Insecta.
d. Chilopoda.

15. (208) What prevents the loss of water through the respiratory system in insects?

a. Gills in the tracheal trunks.
b. Lungs in the abdomen.
c. The presence of humidity in the air.
d. Valves in the spiracles.

16. (208) The reproductive system of egg laying insects is termed

a. larviparous.
b. oviparous.
c. parthenogenesis.
d. vas deferens.

17. (209) Which organs provide the sense of touch in insects?

a. Cuticle and antennae.
b. Cuticle and feet.
c. Hairs and antennae.
d. Hairs and feet.

18. (209) Insect behavior is influenced by all of the following stimuli except

a. light.
b. heat.
c. gravity.
d. memory.

19. (210) Why is it necessary to conduct pest surveys when management programs are already in operation?

    a. To evaluate the effectiveness of the program.
    b. To determine the type of program to be implemented.
    c. To make use of available manpower and equipment.
    d. To determine if the program should be discontinued.

20. (210) A probing survey is used to determine the

    a. presence of pests in hard to reach areas.
    b. damage from past treatments for pests.
    c. presence of potential pest breeding places.
    d. damage from termites, fungi, and wood borers.

21. (211) A primary reason for collecting pests is to

    a. eradicate them.
    b. identify new species.
    c. kill them for testing.
    d. detect and identify disease carriers.

22. (211) What pests are usually collected with a cloth drag?

    a. Ticks.
    b. Mites.
    c. Mosquitoes.
    d. Cockroaches.

23. (211) What prevents ectoparasites from being lost when they are brushed from an anesthetized animal?

    a. They are anesthetized also.
    b. They cannot crawl up the sides of the collection pan.
    c. They are stunned by the brushing.
    d. They are killed by the brushing.

24. (212) What process is used when using keys to identify pests?

    a. Ordering.
    b. Elimination.
    c. Structuring.
    d. Reduction.

25. (212) What do you need in addition to your identification key in order to identify a pest specimen?

    a. A dichotomus and a couplet.
    b. A good specimen in alcohol and a magnifying glass.
    c. A microscope and a specimen in good condition.
    d. A disected specimen and a wall chart.

26. (213) If you wear glasses, what should you do when using a microscope?

    a. Take your glasses off while viewing.
    b. Take your glasses off while adjusting microscope.
    c. Make adjustments with glasses on; do your viewing with glasses off.
    d. Do all adjusting and viewing with your glasses on.

27. (213) How is the proper width of a microscope eyepiece determined?

    a. View with one eye at a time until the field is visible without moving your head
    b. Measure between the centers of your eyes; adjust the same distance to the center of the eyepieces.
    c. Move the eyepieces while viewing; adjust until you see two distinct images.
    d. Move the eyepieces while viewing; adjust until you see a single image.

28. (214) How should you clean specimens that are very fragile or dry and rigid?

    a. With a small camel hair brush.
    b. By immersing in a synthetic detergent and water solution.
    c. By immersing in alcohol or formaldehyde.
    d. With a moistened cotton swab.

29. (214) Which method of pinning is best to use for mounting small dry-preserved specimens?

    a. Carding.
    b. Staging.
    c. Pointing.
    d. Direct pinning.

30. (215) What type of specimens are best preserved in spirits?

    a. Soft bodied specimens.
    b. Very small specimens.
    c. Very large specimens.
    d. Hard crusty specimens.

31. (215) How should spirit preserved specimens be stored?

    a. In a ventilated jar or other container.
    b. In a well lighted warm area.
    c. In a cool, dark area, away from all sources of heat.
    d. Anywhere as long as they are in an airtight container.

32. (216) How should a mold be prepared before filling with plastic resin?

    a. Coat the interior of the mold with uncatalyzed resin.
    b. Apply a mold release compound to the interior of the mold.
    c. Wash the mold and dry in a light bulb oven.
    d. Wash the mold in synthetic detergent and leave wet.

33. (216) What precaution should be taken when stirring a resin and catalyst mixture?

    a. Do not create any bubbles in the mixture.
    b. Use a plastic stirring rod.
    c. Allow bubbles to float to the top and skim them off.
    d. Stir until the mixture begins to thicken.

34. (217) What type of specimens are best suited for slide preservation?

    a. Any specimen which can be made transparent.
    b. Very small, soft specimens.
    c. Specimens no larger than the slide.
    d. Parts of large specimens.

35. (217) How are specimens cleared of internal body tissues prior to slide mounting?

    a. By soaking in alcohol and squeezing the abdomen.
    b. By drawing body fluids out with a hypodermic needle.
    c. By cold soaking in caustic potash solution for 12 hours.
    d. By placing in a vacuum chamber for 12 hours.

36. (218) On a military installation, who is responsible for initiating and supervising the planning and execution of all insect, rodent, and other pest control activities?

    a. Installation commander.
    b. Base civil engineer.
    c. Industrial engineer.
    d. Base medical service.

37. (218) Who is responsible for advice on the control measures and chemicals to be used in an on-base pest management program?

    a. Base medical services.
    b. The base civil engineer.
    c. The environmental protection agency.
    d. The pollution control authority.

38. (219) Which of the following methods of pest control is often used, although it is not the most desirable method?

    a. Local data and records.
    b. County health office information.
    c. After the fact.
    d. National Weather Service information.

39. (220) What is the first step in selecting pest management procedures?

    a. Determine the equipment and material available.
    b. Identify the pests.
    c. Determine the personnel available.
    d. Identify pest locations.

40. (220) All phases of pest management planning should be based on

    a. economy and safety.
    b. effectiveness and economy.
    c. safety and effectiveness.
    d. responsibility and authority.

41. (221) Which of the following sections can be of help to you in the repair of two cylinder engines?

a. Power Production.	c. Pavements and Grounds.
b. Equipment Section.	d. Environmental Support.

42. (222) Which of the following types of controls are instrumental in controlling pests?

a. Dry weather and natural predators.
b. Natural and applied.
c. Pesticides and natural predators.
d. Natural and artificial.

43. (222) Which type of control is best for pest management?

a. Natural.	c. Artificial.
b. Corrective.	d. Preventive.

44. (223) Which control method is considered a biological control?

a. Maintaining proper drainage.
b. Chemical destruction of arthropod pests.
c. Good sanitation practices.
d. Protection of insectivorous arthropods.

45. (223) Which of the following control methods is considered a mechanical control?

a. Proper erection and preparation of facilities and grounds.
b. Traps and barriers.
c. Control of harmful arthropods.
d. Frequent disposal of refuse.

46. (224) The fumigant that is the most beneficial for in-transit fumigation of stored-food pests is

a. hydrogen phosphide.	c. napthalene.
b. paradichlorobenzine.	d. methyl bromide.

47. (224) Which of the following factors is an advantage of mist application over aerosol application?

a. Better penetration of dense vegetation.
b. Better residual effect.
c. Readily adaptable to ULV applications.
d. Less hazardous.

48. (224) Dusting as a means of pesticide application is the preferred treatment

a. to control aquatic pests.
b. in the sub-slab injection for termites.
c. around electrical equipment.
d. for sewage trickling filters.

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49. (224) Baiting is generally used to control

a. mosquitoes.
b. rodents.
c. flies.
d. cockroaches.

50. (225) What type of pesticides are usually used for space treatment?

a. Dusts and granules.
b. Granules and solutions.
c. Emulsions and dusts.
d. Solutions and emulsions.

51. (225) How are space treatments normally dispersed?

a. By misting or spraying.
b. As fog type aerosols.
c. By dusting.
d. With granular dispersal equipment.

52. (226) How does foilage treatment affect plants?

a. Cuts off oxygen supply to the plant.
b. Stimulates desirable plants which smother undesirable plants.
c. Burns tissues or causes excessive hormone growth.
d. Decreases nitrogen food supply.

53. (226) Which type of soil treatment stops the growth of vegetation by preventing seed germination?

a. Selective.
b. Nonselective.
c. Preemergence.
d. Postemergence.

54. (227) An increasing problem for pest managers is the

a. effectiveness of new products.
b. resistance of pests to pesticides.
c. lack of guidelines for new pesticides.
d. initial research that is required before new pesticides can be marketed.

55. (228) How often do pest management personnel who hold a certificate of competency have to be recertified?

a. Semiannually.
b. Annually.
c. Biannually.
d. Every three years.

56. (228) What publications cover the AF Form 483?

a. AFR 91-16 and AFM 91-21.
b. AFR 91-12 and AFM 91-61.
c. AFR 91-21 and AFM 91-16.
b. AFR 19-21 and AFM 19-16.

57. (229) What is AF Form 2467?

a. A pest control historical record maintained at each facility.
b. A pest control historical record maintained in the CE organization.
c. A request for pest control services.
d. A certification of discontinued need for pest control services.

58. (229) How long are the AF Forms 2467 kept on file?

a. 2 years.
b. 3 years.
c. 4 years.
d. 5 years.

59. (230) What type of facilities require a DD Form 1070, Termite and Wood Decay Inspection?

a. All wood facilities.
b. All wood or partial wood facilities.
c. All wood facilities which had no preventive measures taken during construction.
d. All wood or partial wood facilities which had no preventive measures taken during contruction.

60. (230) On base facilities requiring wood pest inspections should be inspected at least

a. semiannually; preferably monthly.
b. quarterly; perferably monthly.
c. annually; preferably semiannually.
d. biannually; preferably annually.

61. (231) How often is the AF Form 290, Transcript for Pest Report, prepared?

a. Daily.
b. Weekly.
c. Monthly.
d. Quarterly.

62. (231) In completing the AF Form 290, the first coded data element entered on the form is the

a. pest name.
b. pest control operation.
c. pest survey.
d. herbicide.

63. (231) On AF Form 290, what type of pest would be indicated by the data code DVMS1?

a. Cockroaches.
b. Adult houseflies.
c. Snails and slugs.
d. Adult mosquitoes.

64. (232) What important amendment was made to the Federal Insecticide, Fungicide, and Rodenticide Act in 1963?

a. Prohibition for agricultural use.
b. Prohibition for commercial sale.
c. Labels stating the contents are harmless.
d. Labels stating "Keep out of reach of children."

65. (232) Agricultural chemicals should be registered every

a. 2 years.
b. 3 years.
c. 4 years.
d. 5 years.

66. (233) How are you, as an entomology specialist, effected by the Federal Environmental Pesticide Control Act?

a. Prohibited the use of restricted pesticides.
b. By the certification requirement.
c. FEPCA does not apply to government personnel.
d. No penalties can be applied to Air Force personnel.

67. (234) What agency has prime responsibility for regulation, research, and education in the field of environmental pollutants?

a. IRS.
b. CIA.
c. EPA.
d. GAO.

68. (235) Which of the following agencies would you contact for help in establishing safe working conditions and procedures?

a. FIFRA.
b. OSHA.
c. FEPCA.
d. EPA.

69. (236) What agency is responsible for developing new or improved occupational safety and health standards?

a. Office of Occupational Safety and Health Administration.
b. U.S. Bureau of Mines.
c. National Institute for Occupational Safety and Health.
d. Bureau of Labor Statistics.

70. (237) Which of the following statutes and/or regulations govern your activities as an entomology specialist?

a. Federal.
b. Federal and State.
c. Federal and local.
d. Federal, State, and local.

71. (238) When a conflict is found between a publication or directive and information on a pesticide label, what should you do?

a. Follow the label.
b. Follow the regulation.
c. Get a clarification from EPA.
d. Get a clarification from OSHA.

72. (238) What is the purpose of the reentry statement on the pesticide label?

a. Tells when re-registration is required.
b. Indicates length of time before pest will reenter the area.
c. Indicates approximate time of presticide effectiveness.
d. Tells how much time is required before a person without protective clothes can enter an area.

73. (238) Which part of a pesticide label is considered one of the most important?

a. Signal Word.
b. Registration and Establishment Number.
c. Misuse Statement.
d. Storage and Disposal Instruction.

74. (239) Which statement best describes the selection of an entomology facility?

a. Space adjacent to other shops with safe storage.
b. Separate from other shops with adequate safe storage.
c. Joint use of existing facilities with other associated specialties.
d. Storage facilities should be in a separate building from shop.

75. (239) For adequate ventilation in a pesticide storage area, a complete change of air is needed at least how many times per hour?

a. Two.
b. Four.
c. Six.
d. Eight.

76. (240) What should be done before entering a pesticide storage area?

a. Turn on exhaust ventilation fan.
b. Put on protective clothing.
c. Notify the fire department.
d. Notify the medical service.

77. (240) What is the purpose of having absorptive clay, hydrated lime, or detergents, available in a pesticide storage area?

a. To absorb pesticide vapors.
b. To clean up pesticide spills.
c. To neutralize pesticide on the skin.
d. To neutralize different vapors to prevent explosions.

78. (241) What action should be taken first when mixing pesticides?

a. Put on protective clothing.
b. Locate a well ventilated area.
c. Read and follow label directions.
d. Know the first aid measures for the pesticide you are using.

79. (241) Which statement best describes why the mixing phase of pesticide handling is so important?

a. You must work alone.
b. Pesticides are unpredictable.
c. Unmixed presticides are flammable.
d. You are working with the most toxic form of the pesticide.

80. (242) In vehicles, how are entomology personnel protected from exposure to pesticide vapors and splashes?

a. Personnel wear protective clothing and equipment.
b. Pesticides are hauled in trailers.
c. All pesticides and equipment are sealed before transporting.
d. The passenger compartment is separate from the storage compartment.

81. (242) Why is a container of water carried on entomology vehicles?

a. Emergency fire protection.
b. Mixing pesticides.
c. Decontamination of skin and eyes in the event of a spill.
d. Drinking.

82. (243) Which phase of pesticide handling presents the greatest threat for contaminating yourself, the environment, and others?

a. Mixing.
b. Application.
c. Transporting.
d. Clean-up.

83. (243) After pesticide application, what should be done before transporting the equipment?

a. Install warning signs on the equipment.
b. Request an escort.
c. Drain the equipment.
d. Release all pressure.

84. (244) What is the most convenient source of instructions for pesticide disposal?

a. The pesticide label.
b. The base medical service.
c. Your shop chief.
d. Sanitation engineering.

85. (244) What publication outlines the procedures for disposing of pesticides and containers which have deteriorated or are unsuitable for return to depot stocks?

a. AFM 19-1.
b. AFR 19-1.
c. AFM 67-1.
d. AFR 67-1.

86. (245) How often should you inventory pesticides?

a. Daily.
b. Weekly.
c. Monthly.
d. Quarterly.

87. (245) Pesticide inventories are taken to determine all of the following conditions except

a. proper utilization.
b. security.
c. container deterioration.
d. proper storage.

88. (246) Who has the final responsibility for insuring that you and your fellow workers wear appropriate protective equipment when handling pesticides?

a. You.
b. Your supervisor.
c. The civil engineer.
d. The director of base medical services.

89. (246) Which of the following statements is true concerning the wearing of protective equipment?

a. Regulations specify safety conditions not safety equipment.
b. Regulations require that protective equipment be worn when specified by job requirements.
c. It is optional and up to the individual.
d. It should always be worn if available.

90. (247) When are entomology personnel authorized to wear coveralls?

a. Anytime.
b. When applying pesticides.
c. When mixing pesticides.
d. When mixing or applying pesticides.

91. (247) A water proof rainsuit is the most appropriate when

a. applying small amounts of liquid pesticides.
b. using fogging machines.
c. handling dermally toxic pesticides.
d. using a fumigating pesticide.

92. (247) What maintenance is required on rubber boots?

a. Washing and sealing.
b. Sealing and lubricating.
c. Lubricating and patching.
d. Washing and lubricating.

93. (247) Which type of gloves is recommended for pesticide handling?

a. Lined leather.
b. Unlined cotton.
c. Unlined neopreme.
d. Lined neopreme.

94. (247) What is the most important factor to consider when using a cartridge type gas mask or respirator?

a. The mask or respirator must matach the pesticide being used.
b. Any cartridge or maskis better then none.
c. The cartridge must match the pesticide being used.
d. A mask must fit loose so you can exhale.

95. (248) The pesticide that is the least toxic to humans is

a. pyrethrum.
b. strychnine.
c. nicotine.
d. hydrogen phosphide.

96. (248) Which of the following compounds affect the protein molecules within certain cells of the body and cause kidney damage?

a. Methyl bromide.
b. Hydrogen sulfide.
c. Hydrogen cyanide.
d. Calcium cyanide.

97. (248) Which of the following symptoms can result from nicotine poisoning?

a. Minor skin allergies, sneezing, and runny or stuffy nose.
b. Severe kidney damage.
c. Extreme nervousness.
d. Paralysis of the respiratory muscles.

98. (249) Which compounds react like organophosphates but are easier to treat?

a. Organochlorines.
b. Botanicals.
c. Carbamates.
d. Fumigants.

99. (249) In order to survive, how soon after poisoning should a victim of strychnine poisoning receive medical aid?

a. Five to six hours.
b. Before ten attacks.
c. Before falling asleep.
d. Before five convulsions occur.

100. (249) Which pesticides cause bruises around the elbows and knees?

a. Fumigants.
b. Botanicals.
c. Petroleums.
d. Anticoagulants.

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101. (250) Accidental pesticide poisoning is caused primarily by

a. poor ventilation and horseplay.
b. inadequate protective gear.
c. ignorance and negligence.
d. poor facilities and procedures.

102. (250) Which of the following measures can be used to prevent accidental ingestion of presticides?

a. Removing or covering food and utensils.
b. Insuring adequate ventilation.
c. Wearing protective clothing.
d. Avoiding smoking while applying pesticides.

103. (251) What is the first thing you should do if you get an absorbed pesticide on your skin?

a. Remove the pesticide as quickly as possible.
b. Remove all your clothing.
c. Seek medical aid.
d. Alert staff of possible side effects.

104. (251) When you are alone with a conscious victim of pesticide poisoning, what is the first thing you must determine?

a. Method of treatment.
b. The distance to the hospital.
c. Method of poisoning: ingestion, absorption, or inhalation.
d. Severity of the poisoning.

105. (252) A poison victim should not be given anything orally

a. if medical personnel are not available.
b. until you know what the poison is.
c. when you want to induce vomiting.
d. if the victim is unconscious.

106. (252) A pesticide poison that has no known effective antidote is

a. sodium fluoroacetate.
b. hydrogen cyanide.
c. pentachlorophenol.
d. nicotine sulfate.

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CDC 56650

ENTOMOLOGY SPECIALIST

(AFSC 56650)

Volume 3

Pest Management,
Chemicals and Equipment

Extension Course Institute

Air University

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THIS PUBLICATION HAS BEEN REVIEWED AND APPROVED BY COMPETENT PERSONNEL OF THE PREPARING COMMAND IN ACCORDANCE WITH CURRENT DIRECTIVES ON DOCTRINE, POLICY, ESSENTIALITY, PROPRIETY, AND QUALITY.

Preface

THIS VOLUME of CDC 56650, *Entomology Specialist*, provides you with knowledge about the following subjects: pesticides and environment, and pesticide dispersal equipment. To become certified as an entomology specialist, you must be knowledgeable in these subjects as well as those that you have covered previously along with those to be covered in later volumes.

Please note that in this volume, we are using the singular pronoun *he, his,* and *him* in its generic sense, not its masculine sense. The word to which it refers is person.

If you have questions on the accuracy or currency of the subject matter of this text, or recommendations for its improvements, send them to Tech Tng Cen/TTGOX, Sheppard AFB TX 76311. NOTE: Do not use the suggestion program to submit corrections for typographical or other errors.

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This volume is valued at 33 hours (11 points).

Material in this volume is technically accurate, adequate, and current as of May 1977.

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NOTE: In this volume, the subject matter is developed by a series of Learning Objectives. Each of these carries a 3-digit number and is in boldface type. Each sets a learning goal for you. The text that follows the objective gives you the information you need to reach that goal. The exercises following the information give you a check on your achievement. When you complete them, see if your answers match those in the back of this volume. If your response to an exercise is incorrect, review the objective and its text.

Pesticides and The Environment

THE WORD "pesticide" has been the subject of many discussions for many years and has really been brought to the attention of the public in recent years through almost all categories of news media. This concern for pesticides is justifiable because most are very toxic, and if not handled properly they can cause severe damage to the environment; however, if they are handled properly, they are a great asset to the environment.

Within this chapter, pesticides that are commonly used will be discribed quite thoroughly, and you will become knowledgeable of how pesticides are classified and formulated. This chapter will also provide information concerning the environmental elements and the effects pesticides may have on the environment.

1-1. Pesticide Classification and Characteristics

In order to select the appropriate pesticide for the pest that is needed to be managed and to manage the pest properly and safely, a knowledge of pesticides is required. This section will present information concerning the methods in which pesticides are classified and will discuss the characteristics of commonly used pesticides.

400. Identify the classification of pesticides in terms of pest to be managed, mode in which it enters the body, and the stage of the pest to be acted upon.

Pesticide Classification Methods. Pesticides are generally classified according to the type of pest to be managed, the mode in which it enters the body (or the mode of action in managing plants using pesticides), and the stage of the pest to be acted upon.

Pest to be managed. The first step that must be taken in classifying a pesticide is to determine what the pest is that needs to be managed. Until now, almost all discussion pertaining to chemicals has been devoted to the term "pesticide," but beginning here, we will be more technical by classifying a pesticide according to the pest to be managed.

As previously stated in Volume 2, a pesticide is a chemical designed to kill pests; but if the pests happen to be insects, then the pesticide would be classified as an *insecticide. Arachnicides* are used to manage Arachnids such as spiders, scorpions, ticks, and mites. Pesticides that are used in managing plants are classified as *herbicides*, and those that are used for managing fungi would be classified as *fungicides*. Notice the manner in which most of the pesticides used for managing each type of pest begins with the pest type and ends with "cide" which means "kill," as in *rodenticide*, a pesticide used to kill rodents such as rats and mice.

Stage of pest acted upon. The second step in classifying a pesticide involves the pest stage to be controlled. The stages are the developmental process of certain insects and are referred to as egg, larvae, papae, and adult. Controls are seldom directed toward the egg stage because this stage is very difficult to locate; furthermore, eggs are difficult to penetrate. The pupae stage is another stage that is not normally controlled because it is the dormant stage in most cases. The larvae and adult stages are the stages most generally controlled because these are the most damaging and they are easier to control.

Using this information, you can understand that insecticides are identified as *ovicides, larvicides, or adulticides,* depending upon the intended use. For example, if the insecticide is to be used for controlling the larvae stage, the insecticide would be further classified as a larvicide.

Along this same order, herbicides can be further classified as being *preemergence* or *postemergence* herbicides. Preemergence herbicides are pesticides designed to kill seeds and immature stages of plants before they break the soil. The postemergence herbicides are designed to kill the top growth of vegetation.

Mode of entry or action. The final step in classifying pesticides is traditionally accomplished according to the method in which it kills.

Pesticides that are designed to kill pests when taken into the digestive system are classified as *stomack*

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poison. Stomach poisons are applied directly to the natural food of pests, mixed into bait material, or sprinkled over runways. These poisons are very effective against certain pests that chew, suck, and have protective shields; they are generally very toxic to humans and other vertebrate animals.

Contact poisons are pesticides that are designed to kill pests through absorption. These poisons are applied directly to the pests or to surfaces the pests will crawl over. Contact poisons are probably used more than any other type of pesticide.

Respiratory poisons are most often referred to as *fumigants.* These poisons are volatile chemicals that kill an organism by entering through its respiratory system and are very useful in managing pests that are difficult to manage by other methods.

Exercises (400):

Complete the following exercises by entering the correct response from the list below in the blank space or spaces.

Arachnicide
Fungicide
Herbicide
Insecticide
Rodenticide
Adulticide
Larvicide
Ovicide
Postemergence
Preemergence
Contact
Fumigant
Stomach

1. A pesticide that is used to manage vegetation would be classified as a ____________.

2. A pesticide that is used to control the eggs of an insect would be classified as an ____________.

3. A pesticide that kills an organism when it is applied directly to the organism or when the organism crawls into it is classified as a ____________ poison.

4. A ____________ is a pesticide that is designed to kill rats and mice.

5. The complete classification of a pesticide that is designed to kill adult mosquitoes when they fly into it is as follows: ________ ________ ________ poison.

6. A pesticide designed to kill seeds and bottom growth of plants is classified as ____________ ____________.

7. The pesticide that would be used in managing spiders would be classified as an ____________.

8. A pesticide that kills by ingestion would be classified as a ____________ poison.

401. Specify characteristics, uses, availability, and safety precautions of arsenical compounds.

Arsenicals. Arsenical compounds used as pesticides are divided into two groups—inorganic and organic.

Arsenicals (inorganic). These compounds are derived from mineral elements, and due to their persistence (ability to remain stable for long periods of time) the majority of them are Restricted Use Pesticides.

Paris green (copper aceto-meta-arsenite) impregnated into vermiculite granules can be used to control certain species of mosquito larvae, providing it is so stated on the pesticide container label. This compound is a nonstandard stock item and should only be used when required and upon approval.

Arsenicals (organic). These compounds are derived from plant and animal matter and are much less persistent then the inorganic arsenicals that were discussed as insecticides. The more common compounds used within the Air Force as herbicides are DSMA, MSMA, and AMA.

DSMA (disodium monomethylarsonate) is a postemergence herbicide that is soluble in water, nonvolatile, and nonflammable. It is formulated as water soluble powders containing 50 to 100 percent hexahydrate, and as dry mixtures with vermiculite containing 2.5 to 4 percent hexahydrate. Total water soluble arsenic in the 50 and 100 percent powders is 12.8 and 25.86 percent, respectively. DSMA is compatible with the salts and esters of 2,4–D and is a standard stock item.

MSMA (monosodium methanearsonate) is used as a selective, contact, postemergence herbicide. It is formulated as a water soluble powder and is very similar to DSMA in action, although it is more phytotoxic and is more effective in high temperatures. It is a nonstandard stock item.

AMA (ammonium methanearsonate) is a selective post-emergence herbicide formulated as a water soluble liquid. This compound is often added to silvex in controlling certain vegetation. This is a nonstandard stock item.

These organic arsenical compounds are considered to be moderately toxic upon ingestion and moderately to relatively nontoxic through absorption; however, protective clothing and equipment must be worn, and there must not be any smoking, eating, or drinking during the handling of these compounds. Always insure that these compounds do not contaminate any water source during or after application.

Exercises (401):

1. Comparing the characteristics of organic arsenicals and inorganic arsenicals, you will find that organic arsenicals are derived from ________ and ________ matter; whereas inorganic arsenicals are derived from ________ elements.

2. The arsenical compounds that are used as herbicides are organic/inorganic arsenicals.

3. The arsenical compound that can be used to control certain species of mosquito larvae is ____________.

4. Of all the chemicals discussed within the arsenical compounds, the only one that can be obtained as a standard stock item is ____________.

5. A common use characteristic of DSMA, MSMA, and AMA is that all three are used as __________ herbicides.

6. Point out the safety precaution that applies to environmental protection.

402. Specify characteristics, availability, and safety precautions of sulfur compounds, and match the organic sulfur compounds with their appropriate use.

Organic Sulfur (Carbamates). In contrast with the inorganic sulfur compounds (to be discussed later), organic sulfur compounds are being used more extensively due to their rapid breakdown within the environment. Common organic sulfur compounds used on Air Force installation are carbaryl, propoxur, EPTC, and SMDC.

The carbamates are derivatives of carbamic acid. Typical carbamates contain nitrogen but differ from the chlorinated hydrocarbons and organophosphate insecticides in their lack of chlorine and phosphorus. Most carbamates are contact insecticides, lowering the cholinesterase level and acting as nerve poisons in much the same manner as organophosphate insecticides. A number of carbamates, such as carbaryl, produce a rapid knockdown of insects similar to the action of pyrethrum.

Carbaryl (Sevin) is widely used in Air Force pest management programs to control a variety of pests. It has a low mammalian toxicity but is highly toxic to honey bees. Carbaryl dusts are used at two to five percent concentrations to kill fleas on dogs and cats (except kittens and puppies under 4 weeks of age). Since the restrictions on the use of DDT in the United States, carbaryl dust has been one of the insecticides of choice to kill the Oriental rat flea in murine typhus control programs and wild rodent fleas in rural plague control programs. Carbaryl sprays and dusts have been used to control adult mosquitoes. Very finely powdered carbaryl combined with other insecticidal dusts has been used effectively in aircraft disinsection. This compound is probably most often used in controlling ornamental and turf pests and is a standard stock item.

Propoxur (Baygon) acts both as a stomach poison and contact insecticide. In cockroach control, the 2 percent bait acts as a stomach poison, while the 1 percent spray acts as a long lasting residual contact insecticide. Propoxur differs from many other insecticides in having a "flushing action," or irritating quality that forces insects out from hiding places to make greater contact with sprayed surfaces. It also has a rapid knockdown action. In some areas, staining and odor problems have been noted following applications. Propoxur is also used in controlling mosquitoes, flies, sand flies, ants, earwigs, and many other arthropods. In residual applications, it is effective in controlling the brown dog tick, but propoxur should not be used in treating animals themselves. Propoxur is a cholinesterase inhibitor and must be used with care despite its moderate toxicity to mammals. This compound is a standard stock item.

EPTC (S-Ethyl diprophlthiocarbamate) is a nonstandard stock selective herbicide applied as a preemergence. It is formulated as granules or water soluble liquid (emulsifiable concentrate). This compound is more effective on grasses than on broad leaf plants and can be mixed with 2,4–D.

The acute oral toxicity of carbamates is high, but the acute dermal toxicity is low; however, as in all cases, when handling any pesticide you must wear protective clothing and equipment and you must observe the very important rule of no smoking, eating, or drinking while handling these compounds. NOTE: *SMDC is used as a fumigant; therefore, it will be discussed later within this section along with the other fumigant compounds.*

Exercises (402):

1. Match the organic sulfur compounds in column A with the appropriate use in column B.

Column A Compound	*Column B Use*
____ a. Carbaryl.	(1) Residual treatment for cockroach control.
____ b. EPTC.	(2) Fumigant that is used for pest vegetation control.
____ c. Propoxur.	(3) Selective preemergence treatment for grass control.
	(4) Disinsection of aircraft.

2. Why are carbamates being used more extensively today?

3. Name the organic sulfur (carbamate) compound that is used as a fumigant is pest vegetation control programs.

4. What is a disadvantage in using propoxur in some areas?

5. Despite Baygon's moderate toxicity to mammals, care must be taken during handling because it is a ____________ inhibitor.

6. The carbamate compound that produces a rapid knockdown of flying insects is ____________ .

7. List the two safety precautions that must be taken as personal protective measures while handling organic sulfur compounds.

8. Most carbamates are available as ____________ stock items.

403. Cite characteristics, uses, availability, and safety precautions of botanical compounds.

Botanicals. These are organic compounds that are derived from plants and are used extensively in pest management programs. They may be used as contact sprays and as stomach poisons, depending upon the compound. The botanical compounds most often used by Air Force personnel as insecticides are pyrethrum and nicotine sulfate.

Pyrethrum is extracted from the flower head of the *chrysantherum cineraniaefolium* and is used as a contact insecticide. It is relatively unstable and is readily decomposed by alkalies, light, and air and is most generally used as a space spray.

This insecticide provides quick knockdown of flying insects but is one of the least toxic insecticides of all to warm blooded animals.

Pyrethrum is available as a standard stock item in the 0.6 percent aerosol and the 0.4 percent solution forms.

Nicotine sulfate is derived from the alkaloid nicotine contained in the tobacco plant and is obtained from the wastes of cigar and cigarette manufacturing industries. Decoctions of tobacco have been used against sucking insects for many years prior to now.

The 40 percent solution of nicotine sulfate is the only forumula of this insecticide that is available for use by Air Force personnel. It is a nonstandard stock item and is used in the control of spider mites as residual contact sprays on ornamental plants.

Although these botanicals are considered to be contact compounds, they do have some fumigating properties; therefore, when handling these compounds avoid inhalation by wearing appropriate respiratory devices and wear protective clothing and goggles.

Strychnine is the only botanical compound used by the Air Force as a rodenticide at the present time. Strychnine is a white powder, practically insoluble in water but is readily soluble in chloroform and certain other organic solvents; however, it can only be obtained by Air Force personnel in the form of a premixed bait. Its authorized use by the Air Force is restricted to controlling prairie dogs and moles and is a nonstandard stock item.

Prairie dogs are protected by Federal laws; therefore, you must consult with the Fish and Game authorities before implementing any control programs against prairie dogs.

Strychnine is highly toxic if ingested; therefore, you must take every precaution available to avoid contamination of all food and water sources and to prevent children and animals from coming into contact with it.

Exercises (403):

1. Botanical compounds are ____________ and are derived from ______________ .

2. Name the characteristics of pyrethrum that could be considered as disadvantages or as advantages.

3. What is the botanical compound that is used as a rodenticide?

4. Although the botanical compounds that are used as insecticides are primarily considered to be __________ compounds, they also have some __________ properties.

5. Name the botanical compound that is applied as a residual contact spray to ornamental plants.

6. What is the only botanical compound that is available as a standard stock item?

7. What is the safety precaution that must be taken to protect the environment from botanical poisons?

404. Specify characteristics, availability, and safety precautions of organochlorine compounds, and match the organochlorine compounds with their appropriate uses.

Organochlorines. Organochlorines (chlorinated hydrocarbons) are organic synthetically produced compounds that contain chlorine, hydrogen, and carbon elements, with some containing other elements such as oxygen and sulfur. These compounds are very persistent and contributed immensely to the recent concern of pesticide use spoken about previously. Because of this, most organochlorine formulations have been classified as Restricted Use Pesticides, which means that they can only be used in specific situations and by certified personnel or personnel under their direct supervision.

There are five organochlorine compounds that are available at this date for use by Air Force personnel. Dieldrin, chlordane, lindane, chlordecone, and Methoxychlor are available for use in specific situations as pesticides even though they are *restricted*. Only dieldrin, chlordane, and lindane can be obtained as standard stock items and only then in certain formulations.

Dieldrin is a tan, flaky, solid in its purest form and is commercially available in various formulas, but is only available to the military in a 15 percent emulsifiable concentrate form. It is highly toxic to most insects when used as a contact or stomach poison and is highly persistent and effective in the control of termites.

Chlordane is a pale amber, oily fluid that can be dissolved in many solvents—but not in water—to produce oil solutions, emulsifiable concentrates, or formulated as wettable powders, and dusts. Chlordane acts as a stomach poison, contact insecticide, and fumigant. Because of its volatility, chlordane is not recommended for general indoor use, but it is effective and allowed to be used outdoors in treating for termites.

Lindane is the gamma isomer of benzine hexachloride (heck-sa-KLO-ride), a chlorinated hydrocarbon insecticide which has been used extensively since World War II until it was placed on the Restricted Use List. It is a colorless, crystalline solid, practically insoluble in water, slightly soluble in petroleum oils, and soluble in acetone, aromatic, and chlorinated solvents. Lindane has a slightly musty odor and has considerable fumigating properties. It is a relatively stable compound but is dehydrochlorinated by alkali. Lindane can be used in specific situations for controlling pests such as carpet beetles, powder post beetles, lice, and millipedes, if so stated on the pesticide label.

Chlordecone (Kepone) is a chlorinated polycyclic ketone compound. It is used as a stomach poison to control ants and cockroaches and is prepared in bait material such as peanut butter. In specific situations, Kepone baits are authorized for use by certified Air Force personnel in controlling cockroaches as a supplement to residual sprays, providing the pesticide label permits.

This poison bait must not be used in places that are accessible to children and pets, since it is very toxic to mammals. Always handle with rubber gloves or equivalent type and avoid contamination of other food and water sources. Adhere to the no smoking, eating, and drinking while handling pesticides rule.

Methoxychlor is related to DDT. It is less toxic to mammals than DDT and is considered one of the safest of insecticides. It is used to replace DDT in many household sprays and aerosols because of its low toxicity to humans, its tendency to be metabolized and excreted in the urine by vertebrates, and particularly its biodegradability. Since it breaks down within weeks after its application and does not remain as a residue in the environment, it is authorized for use by certified Air Force personnel in the control of black flies if the pesticide label so states.

Exercises (404):

1. Why are organochlorines called chlorinated hydrocarbons?

2. Why are almost all organochlorine compounds Restricted Use Pesticides?

3. What organochlorine compound is used as a replacement for DDT in many household sprays and aerosols?

4. How are organochlorine compounds produced?

5. List the individuals who can use Restricted Use Pesticides.

6. Match organochlorine compounds with their appropriate uses and characteristics:

Compound		*Uses and Characteristics*
____ a. Chlordane.	1.	Easily soluble in acetone, has a musty odor, and is used for controlling carpet beetles.
____ b. Chlordecone.	2.	Prepared as a bait material and is used as a stomach poison to control cockroaches.
____ c. Lindane.	3.	Considered to be less toxic than DDT to mammals and may be used to control black flies.
____ d. Methoxychlor.	4.	Acts as a stomach poison, contact poison, and respiratory poison, and is used in termite treatment programs.
	5.	Can only be obtained in the 15 percent E/C by the Air Force and is only authorized to be used in control of termites.

405. Specify characteristics and safety precautions of organophosphate compounds, list the organophosphates that are available as standard stock items, and match the organophate compounds with their appropriate uses.

Organophosphates. These compounds are synthetically produced and are basically derived from phosphoric acid and are characterized by their similar structure and mode of action. All of them work as inhibitors of the enzyme cholinesterase.

In the early 1970s, the organophosphate insecticides played much the same role in controlling arthropods of medical importance as did the chlorinated hydrocarbons from the middle 1940s to the middle 1960s. The organophosphates have almost completely replaced the chlorinated hydrocarbons as the pesticides of choice because they are effective against insects resistant to the organochlorine compounds and they are biodegradable; therefore, they do not contaminate the environment for very long, have less long-lasting effects on nontarget organisms.

The greatest advantage of organochlorine compounds from the medical standpoint is that they are considered to be nonaccumulative in the body of humans. Therefore, these compounds will dissipate through the functions of the normal body system after a short period of time as compared to organochlorines.

Since the majority of insecticides authorized for use by Air Force personnel consists of organophosphates, they will be separated into three groups for easier discussion.

Malathion group. This group is made up of open chain compounds as distinguished from aromatic hydrocarbons containing phosphorus, and is sometimes referred to as the aliphatic derivatives of phosphorus compounds which include Malathion, dichlorvos, dimethoate, naled, and trichlorfon.

Malathion is one of the safest and most useful of insecticides, being a far less active cholinesterase inhibitor than most other common organic phosphates. It has a less adverse effect upon the natural habitat than more persistent insecticides and, in general, has replaced DDT as the chemical of choice for killing adult mosquitoes, bedbugs, and human lice.

Technical grade malathion is a clear amber fluid which can be incorporated into solutions, emulsifiable concentrates, dusts, and wettable powders. The odor-causing impurities have largely been removed in present-day, premium grade materials. Malathion is registered for the control of more than 100 species of insects and is a standard stock item within the Air Force inventory.

Residual application of malathion to surfaces at a rate of 100 to 200 milligrams per square foot (standard applications of 1 to 2 gallons of 2.5 to 5 percent sprays are 1000 square feet) have given effective kill of mosquitoes for 3 to 5 months. When used as a fog or mist in space spraying, excellent mosquito kills have been obtained. Ultra-low volume space application of malathion with groud or aerial equipment has resulted in spectacular control of mosquitoes in many areas.

Dichlorvos (DDVP or Vapona) was synthesized and tested by research workers at the Center for Disease Control. It differs from most other insecticides in that it can be incorporated into resin strips or pellets, to give off toxic vapors for up to 4 months, and thus to be used as a *residual fumigant.* DDVP resin strips, a standard stock item, are sold commercially and used by the general public to control cockroaches, ants, spiders, clothes moths, silverfish, and many other household insects. The Air Force uses these strips for inclusion into retrograde cargo.

Dichlorvos emulsions, a nonstandard stock item, can be used as residual sprays or as space sprays for controlling pests such as bedbugs, biting midges, mosquitoes, and stored products pests.

Dimethoate (Cygon) has been proven effective as a space spray and larvicide in controlling flies. As a residual spray it is effective in controlling most common fly species except the housefly, although it is recommended for controlling housefly larvae. Other uses of Dimethoate allowed by the Air Force are for controlling spider mites and scale insects. This compound is a nonstandard stock item and must be obtained through local purchase.

Naled (Dibrom) is closely related to dichlorvos (DDVP), two bromine atoms being added to the molecular structure. It is a contact and stomach poison. This material is a standard stock item and is generally used in space sprays for control of adult mosquitoes and flies at application rates of from 0.02 to 0.1 pound per acre, significantly lower dosages than are used with malathion for mosquito control. Naled aerial applications are reported to provide better adult fly control than malathion, a factor of some importance in vector control in disaster or flooded areas. Naled is approved for aerial ULV application and has provided excellent control of flies and mosquitoes in many areas. It is also used as a bait or spot treatment for houseflies out-of-doors. It is sometimes irritating to people, causing them to cough and sneeze, thus limiting its usefulness in populated areas. Naled can cause corrosion of insecticidal equipment, and requires special cleaning precautions or the use of special materials such as stainless steel, plastic, or fiberglass.

Naled must be used with care to avoid hazards to fish and wildlife, although it breaks down chemically within a few days after application. It has moderate toxicity to humans. Naled can be obtained as a standard stock item.

Trichlorfon (Dipterex) is approved for use by the Air Force only in the treatment for white grubs on golf courses, parks, ornamental turf, and cemeteries; however, it is a nonstandard stock item and must be ordered through local purchase.

When used with normal precautions, trichlorfon creates a very low toxic hazard to insect controllers and the public. It should not be mixed with malathion, because the resultant mixture is more toxic to mammals than either of the chemicals used separately.

Parathion group. This group of insecticides have one or more phenyl radical in common and at times are referred to as the Aryl (Phenyl) derivatives of phosphorous compounds which include abate, fenthion, rabon, and ronnel.

Abate is very effective as a mosquito larvicide but not as an adulticide. Its extremely low toxicity to mammals, birds, and fish, plus its high toxicity to mosquito larvae make it very effective for mosquito control. Abate may be applied by ground or aerial equipment.

The one percent Abate sand formulation was used in the *Aedes aegypti* eradication program at the rate of one-tenth teaspoonful per gallon of water, or approximately one part per million of actual toxicant. It may be used at this rate for the treatment of birdbaths, animal drinking containers, and drums of rainwater. Because rainwater is often used for drinking or cooking in Puerto Rico and the Virgin Islands, a careful evaluation of Abate was made for 4 weeks without clinical symptoms or side effects attributable to Abate and without detectable effect on red blood cell or plasma cholinesterase. Abate is a nonstandard stock item within the Air Force inventory.

Fenthion (Baytex) is an organophosphate insecticide that provides quick kill and long-lasting residual effects. This is a nonstandard stock item and is only authorized to be used in controlling adult mosquitoes in Florida and Texas; and even then, it must be applied by certified personnel using ground equipment.

Rabon (Gardena) is a relatively new contact insecticide, and thus far its use is limited within the Air Force to tick and mite control. It has low mammalian toxicity and prospects of being used in mosquito control programs. This is a nonstandard stock item and, as in all cases, adherence to the pesticide label is mandatory.

Ronnel (Korlan) is a contact insecticide which is useful in fly and flea control. It has low toxicity to humans; however, is a nonstandard stock item. Residual treatments have been used to control houseflies for up to a week or more. Such treatments are more effective against other species, such as the little housefly, that have resting habits similar to those of the housefly. Ronnel is also authorized for use in controlling dog and cat fleas when applied indoors as a residual, provided label recommendations are followed.

Diazinon group. The common insecticides authorized for use in Air Force pest management program within this group include diazinon and chlorphyrifos.

Diazinon, a standard stock item, is authorized and widely used by Air Force personnel in controlling cockroaches, silverfish, fleas, spiders, and many other household pests. It is more toxic to humans than malathion; therefore, only the 0.5 percent spray and 1 percent dust are used. Pyrethrins or dichlorvos may be added to diazinon sprays to provide a rapid knockdown or a flushing of cockroaches, thus producing a more effective kill.

Spray solutions should be diluted not more than 24 hours before use. The solvent used in formulations may stain certain plastic, rubber, and asphalt materials such as tiles and floor coverings. Dust applications may be used to supplement spray applications for more complete coverage.

Chlorpyrifos (Dursban) acts as a contact insecticide and stomach poison with some fumigant action in field formulations. It has proved effective in controlling a wide variety of arthropod pests. The 0.5 percent spray of chlorphrifos has given longer periods of control of cockroaches in some experiments than either diazinon or propoxur.

In mosquito control, it has shown promise as a larvicide and adulticide. It is highly toxic to mosquito larvae, with a LD95 value of 4.5 parts per billion against *Aedes aegypti*. Dursban is effective against culex larvae in polluted waters. It has also been used as a prehatch treatment to control temporary pool mosquito larvae. For example, *Aedes vexans* larvae were controlled in Minnesota where it was effective for periods of more than 60 days. Although Dursban was not labeled for ULV (ultra low volume) application with ground or aerial equipment as of February 1973, experimental work with backpack ULV sprayers in Minnesota gave a good reduction of aedes mosquitoes.

Since Dursban is slow acting against many insects, dichlorvos or pyrethrins may be added to sprays to give a rapid knockdown. Mixtures of 0.5 percent Dursban with 0.5 percent pyrethrins or 0.5 percent DDVP produced rapid knockdown of cockroaches and 100 percent mortality in laboratory tests. It is less expensive to use 0.5 percent dichlorvos than the higher concentration of Dursban.

Dursban, a standard stock item, is moderately toxic to warm blooded animals. Heavy application of 0.5 percent emulsions and suspensions in *Aedes aegypti* larviciding has decreased the plasma cholinesterase level in applicators.

Exercises (405):

1. How are organophosphate compounds produced, and from what are they basically derived?

2. The extensive use of organophosphate compounds began in the early ____________.

3. Organophosphate compounds have almost completely replaced organochlorine compounds in the control of medically important arthropods because organophosphates are effective against insects that are ____________ to organochlorine compounds.

4. What are the advantages that organophate compounds have over the organochlorine compounds?

5. Organophosphate compounds are devided into three groups; these groups are _______, _______, and ___________.

6. List the organophosphate compounds that are available as standard stock items within the Air Force in one form or another.

7. **Match organophosphate compounds with their appropriate use.**

Compound	*Use*
____ a. Abate.	1. Very effective for controlling mosquitoes when applied as residuals, fogs, or mists.
____ b. Diazinon.	2. Widely used by Air Force personnel in controlling cockroaches.
____ c. Dichlorvos.	3. Very effective as a mosquito larvicide but not as an adulticide.
____ d. Dimethoate.	4. Authorized to be used in controlling dog and cat fleas when applied indoors as a residual if so stated on the pesticide label.
____ e. Malathion.	5. Use is limited within the Air Force to control ticks and mites.
____ f. Rabon.	6. Resin strips prepared from this compound are used within the Air Force for placement into retrograde cargo.
____ g. Ronnel.	7. Authorized for use within the Air Force for controlling spider mites and scale insects, if label so states.

406. Point out characteristics, uses, availability, and safety precautions of benzoic acid compounds.

Benzoic Acids. These compounds are readily translocated in the plant. They kill through both root and foliage absorption. They are good temporary soil sterilants for both perennial and annual weeds.

2,3,6,–TBA is formulated as the dimethylamine salt of trichlorobenzoic acid, containing 2 pounds per gallon acid equivalent. It is nonvolatile, noncorrosive, and nonflammable. It is a mild skin irritant. It is compatible with 2,4–D amine, dalapon, diuron, and monuron.

PBA is a mixture of a small amount of 2,3,6-Trichlorobenzoic acid and a higher proportion of several other polychlorobenzoic acid derivatives. It is formulated as the dimethylamine salts of polychlorobenzoic acids, containing 4 pounds per gallon, acid equivalent. It is nonvolatile, noncorrosive, and nonflammable. It is a mild skin irritant. It is compatible with 2,4–D amine, dalapon, diuron, and monuron.

PBA and 2,3,6,–TBA are more effective than 2,4–D, 2,4,5–T, or silvex on bindweed, field; bur-franseria; cockle, white; halogeton; knapweed, Russian; spurge, leafy; and thistle, Canada.

Dicamba is formulated as the demethylamine salt of 2-methoxy-3, 6-dichlorobenzoic acid in water, containing 4 pounds, acid equivalent, per gallon.

It is very effective on several hard-to-kill broad-leaved weeds, such as buckwheat, tartary; garlic, wild; knotweed, prostrate; Russian-thistle; smart-weed, green; sowthistle, perennial; spurry, corn; thistle, Canada; and wild buckwheat.

Of these three benzoic acid herbicides, only Dicamba is a standard stock item. The others must be obtained through local purchase.

When handling these compounds, wear protective equipment and clothing. Avoid drifts so that desired vegetation will not be affected and water sources will not be contaminated.

Exercises (406):

1. Benzoic acids are readily ________ in plants and are very effective as temporary soil ____________.

2. The benzoic acid compounds that are more effective for controlling bindweed, knapweed, and spurge than 2,4–D, 2,4,5–T, or silvex are ___________ and ____________.

3. The benzoic acid compound that is very effective on hard-to-kill broad-leaved weeds such as buckwheat, knotweed, and wild buckwheat is ____________.

4. Of the three benzoic acid compounds discussed, the only one that is a standard stock item is ______________.

5. What should you do to avoid personal contamination?

407. Cite characteristics and uses of aliphatic acid compounds, and list the safety precautions to be observed with aliphatic acids.

Aliphatic Acids. These compounds are relatively strong acids and are primarily used as herbicides. They are derived from sodium salt and are usually obtained in powder or pellet forms. They are water soluble and are used principally as selective translocative preemergence and postemergence herbicides. The two most common aliphatic acids utilized in the Air Force are Dalapon and TCA.

Dalapon (2,2-Dichloropropionic acid) is formulated as the sodium salt of dichloropropionic acid. It is a water-soluble powder applied in solution for foliage spray. A typical commercial product available as a standard stock item within the Air Force inventory contains 85 percent of the salt or 74 percent of the acid equivalent. The acute oral toxicity is low. It is not absorbed through unbroken skin. Undiluted, it may cause skin irritation after prolonged contact, but spray concentrations are not irritating. The powder or concentrate solutions can cause painful irritation of the eyes. Dalapon is used principally to control grasses, but it is also effective against cat tails; pine, jack and white; phragmites; rushes; and white-cedar. It is a growth-regulator type of herbicide that is translocated from leaves to roots and rhizomes of perennial grasses. It is more effective in foliar applications than TCA, but it is also absorbed by the roots. For general weed control, it is mixed with a broad-leaved weedkiller such as 2,4–D, amitrole, or silvex. Dalapon disappears from the soil most rapidly in warm and humid regions. It persists longer in dry, cool soils where microbial activity is low.

TCA (Trichloroacetate acid) is very similar to Dalapon, but a typical commercial product contains a higher percentage of sodium salt; therefore, it is basically used as a temporary soil sterilant. TCA is a nonstandard stock item within the Air Force inventory.

Do not apply these compounds near desired vegetation or irrigation water or when heavy rains are expected, because these compounds have a tendency to leach out of top soil.

Wear protective clothing and equipment, avoid drift, and wash spray equipment immediately following use because these compounds are very corrosive.

Exercises (407):

1. Aliphatic acids are derived from ______________ and are used as ______________ herbicides.

2. Aliphatic acids may be applied as ___________ or ____________ herbicides.

3. What aliphatic acid compound is used basically as a temporary soil sterilant?

4. Dalapon is primarily used to control ___________.

5. List the environmental safety precautions that must be observed when using aliphatic acid compounds.

6. Equipment that has been used to apply aliphatic acid compounds should be ________ immediately because these compounds are __________.

408. Specify characteristics, uses, and availability of phenoxy compounds.

Phenoxys. The phenoxy compounds include 2,4-D, MCPA, 2,4,5-T, and silvex. In the acid form, these herbicides are only slightly soluble in water. For commercial use, they are formulated as esters, which form milky emulsions with water and also dissolve in light oils, or as water soluble salts. The amines are the most widely used salts. They are easily soluble in water and are commonly sold in liquid form. There are also sodium and ammonium salt formulations that are sold as water-soluble powders, but they are not so effective as the amine salts on hard-to-kill species or on weeds that are in bud stage and beyond. All of the salts are practically nonvolatile. Two general kinds of esters are commercially available: relatively high-volatile esters and relatively low-volatile esters. Although the low-volatile esters vaporize less rapidly, both types are volatile at high temperatures. Drift can occur with any of the formulations if the spray is in very fine droplets or mist and there is a wind.

The phenoxy furmulations are moderately toxic. The hazard to livestock and wildlife is negligible on treated vegetation, but toxic amounts could be eaten if animals had access to undiluted concentrates or large amounts of spray mixtures. As ordinarily handled, these materials are not likely to cause irritation to skin or eyes. They are not absorbed through the skin to any appreciable extent and, in the amounts likely to be inhaled, are not hazardous. Neither is the ingestion of harmful amounts likely. At dosages used for weed control, they may harm fish in still, shallow water. They are noncorrosive and nonflammable.

2,4-D is formulated as water-soluble sodium, ammonium, or amine salts and volatile or low-volatile esters. Sodium salts and esters are also available as dusts. A new formulation is the diamine salt. It is an oil-soluble amine that has the week-killing properties of an ester and the nonvolatile features of amine salts. It is formulated in a concentrate containing 2 pounds, acid equivalent, per gallon.

2,4-D is used for the control of herbaceous broadleaved weeds. It can be applied at extremely low concentrations compared with the inorganic herbicides, such as borates and chlorates. It is absorbed through leaves and is readily translocated in the plant, but it is also absorbed by plant roots. It is commonly used as a selective herbicide rather than soil sterilant. Its effect, when applied to the soil, is temporary except under very dry conditions or cool weather. 2,4-D is used on many perennial broad-leaved weeds, since it is translocated to the roots and underground storage organs. It is carried with the sugars as they move out of the leaves. It is, therefore, most effective on warm sunny days when photosynthesis is active. It is a very useful herbicide to kill annual nongrass weeds that frequently reinfest an area treated with a soil sterilant after it has leached below the surface layer. It is also an inexpensive and convenient chemical to kill certain weeds that are tolerant to a soil sterilant. On roadsides and similar areas where grasses are desirable for erosion control and in turf, 2,4-D can be used selectively to kill broad-leaved plants in sod. 2,4-D is also effective on certain broad-leaved aquatic plants. It is also used for the control of woody plants. The salt formulations are practically nonvolatile, but, with the possible exception of the diamine salt, are less effective than the esters on hard-to-kill species. The low-volatile esters are equally as effective as the volatile esters and in some instances are better. Some woody species are tolerant to 2,4-D but susceptible to 2,4,5-T and vice versa. For use on mixed populations, the two herbicides are combined in a formulation sold as "brush killers." These brush killers contain one-third to one-half 2,4,5-T and two-thirds to one-half 2,4-D. Brush killers are also effective on poison ivy, poison oak, and poison sumac.

The esters are used extensively in oil for basal-bark, stump, and cut-surface applications. Diesel oil, kerosene, and water are used as carriers. They are used in the fall and winter on deciduous trees when there are few active leaves present or in the summer to increase penetration of leaves, bud scales, and bark. Water is commonly used as the carrier with ester in emulsion for foliage sprays. Only small amounts of oil can be used for this latter purpose (up to 10 gallons per acre), since oil kills leaf tissue and hence prevents movement of the chemical to the roots.

MCPA contains several isomers, but the 2-methyl-4-chloroisomer is the most effective for killing weeds. Therefore, the better formulations contain a high proportion of this isomer. The most widely used formulations are the sodium and amine salts. MCPA is very similar in use as 2,4-D, because it too, is used in controlling herbaceous broad-leaved weeds; however, it is more expensive.

2,4,5-T is generally used in the ester formulation, although there are sodium and triethanolamine salts. There is also a new diamine formulation containing 2 pounds, acid equivalent, per gallon; 2,4-D and 2,4,5-T are also combined in a formulation called *brush killer.*

This chemical can be used for the selective control of broad-leaved weeds in turf and for some emersed aquatics of nongrass species, but it is used principally for the control of woody plants. Like 2,4-D, it is a growth-regulator type of herbicide that can injure nearby broadleaved plants through drift. Handling precautions are the same as for 2,4-D. The salt formulations are practically nonvolatile but, with the possible exception of the diamine salt, are less effective than the esters on woody plants. The low-volatile esters are equally effective as the volatile esters and in some instances are better.

Some woody species are tolerant to 2,4-5-T but susceptible to 2,4-D and vice versa. Brush killers are used on mixed populations.

Silvex is an organic acid that is formulated as a low-volatile ester, a liquid potassium salt, and a granular

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product. When emulsified with water or an oil-water carrier, the ester formulation is used as a selective translocated foliar spray to control many broadleaved weeds and some woody plants. Commercial products are formulated of mixed propylene glycol butyl ether esters, a butoxyethanol ester, or an isooctyl ester of silvex to contain 4 pounds, acid equivalent, per gallon. Undiluted, the esters are very painful to the eyes and irritating to the skin; but in diluted spray mixtures, they are only mildly irritating. In acute oral toxicity, they are similar to esters of 2,4–D and 2,4,5–T.

Ester formulations of silvex are used in much the same way as esters of 2,4,5–T except that (1) they are safer where drift onto cotton is a hazard; (2) they are more effective as a foilage spray on maple, redbud, Cherokee rose, saltcedar, and trumpet creeper; (3) they are not so effective for basal-bark and cut-surface applications; and (4) they are more effective on mouse-ear chickweed, henbit, and yucca.

The liquid salt formulation is a solution of the potassium slat of silvex containing 6 pounds, acid equivalent, per gallon. It is used to control aquatic weeds. This formulation is less toxic than the ester formulations to fish except brown trout. It does not injure land plants growing adjacent to treated areas. It is similar to 2,4–D in its effect on many species of submersed aquatic weeds and is more effective on some. Handling precautions are similar to those for the ester formulations.

The granular product contains 20 percent acid equivalent. It is used to control the same aquatic weeds as the liquid salt. Handling precautions are similar to those for the liquid salt and esters except that there is more danger of inhaling dust and less danger of skin irritation. Toxicity to fish is the same as for the liquid salt.

All phenoxy compounds that have been discussed are available as standard stock items within the Air Force inventory except MCPA.

Protective equipment and clothing are required while handling these compounds. Apply these compounds in a manner that they will not contaminate portable water sources.

Exercises (408):

1. Phenoxy formulations are ____________ toxic.

2. List the advantages of using phenoxy compounds for the operator when they are applied at the recommended rate and strength.

3. The phenoxy compound 2,4–D is used to control ____________ weeds.

4. The phenoxy compound that is principally used for controlling woody plants is ____________.

5. When 2,4–D and 2,4,5–T are combined in a formulation, this preparation is sold as a __________ __________.

6. The liquid salt formulation of silvex is used to control ____________ weeds.

7. The formulation of silvex that is used in much the same way as 2,4,5–T is the ____________ formulation.

8. The phenoxy compound that is not available as a standard stock item is ____________.

409. Identify characteristics, uses, availability, and safety precautions of phenylurea compounds.

Phenylureas. These compounds used for soil sterilants include monuron, diuron, and fenuron. They are only slightly soluble in water, low volatility, noncorrosive, and nonflammable. They are formulated as water-dispersible powders and granular products. With the exception of the granular materials, all forms are applied as suspensions in relatively large volumes of water and require agitation in the spray tank.

Although these chemicals do not move far laterally in the soil, they may be washed down the surface of slopes to kill vegetation below and they leach deeply enough to reach the roots of trees, shrubs, and other deep-rooted plants growing under the treated area. All three chemicals can irritate eyes, nose, throat, and skin.

Monuron is formulated as a water-dispersible powder containing 80 percent active ingredient. It is also formulated as a granular material.

The effects of monuron on all weeds are slow to appear. Monuron is more effective in light sandy soils than in heavy types at equivalent rates and is more active in mineral soils than those high in organic-matter content. It is much more soluble in water than diuron, so it is better adapted to areas of less than 25 inches of rainfall a year except along irrigation and drainage ditches. It is also preferred to diuron for soils containing considerable amounts of clay, especially bentonite, or of organic matter. At high rates, it leaches readily from sandy soils and moves downward twice as fast as diuron in both clay and sandy soils. It is somewhat more effective on grasses than nongrasses and gives better control than sodium chlorate. Heavy rainfall and standing or running water; conditions favoring microbial activity such as warm soils of high organic-matter content and moisture; and soil cultivation shorten its persistence in the soil. Sterility of the soil may last 1 to 3 years; this depends on rates applied, soil type, and rainfall.

Diuron is even less soluble in water than monuron. It is formulated as a water-dispersible powder containing 80 percent active ingredient. There is also a liquid suspension, containing 2.8 pounds per gallon, active ingredient.

The effects of diuron on all weeds are slow to appear. Diuron is more effective than monuron where rainfall is over 25 inches a year and especially on sandy soils. It is not recommended for areas of low rainfall, especially to control deep-rooted plants. Larger amounts of diuron then monuron are absorbed by all soils; consequently, it is more persistent.

Fenuron is more soluble in water than monuron or diuron, but still only small amounts can be dissolved (0.02 pound per gallon water). It is formulated as a 25 percent pelleted product. It is inactivated more rapidly than monuron or diuron and is adapted as a soil sterilant only for dry areas.

Of the three phenylurea compounds discussed, Fenuron is the only one that is a nonstandard stock item.

As with all pesticides, protective equipment and clothing must be worn while handling these compounds, and precautions must be taken to avoid damage to desirable plants and contamination of water sources.

Exercises (409):

1. What is the primary use of phenylurea compounds?

2. Match phenylurea compounds with their appropriate use?

Compound	*Use*
___ a. Diuron.	(1) Soil sterilant for dry areas.
___ b. Fenuron.	(2) Most effective as a soil sterilant where rainfall is over 25 inches a year and especially on sandy soils.
___ c. Monuron.	(3) Most effective as a soil sterilant where rainfall is less than 25 inches a year.

3. The two phenylurea compounds that are standard stock items within the Air Force are ___________ and _____________ .

4. List the safety precautions for using phenylurea compounds.

410. Specify characteristics, uses, availability, and safety precautions of triazine compounds.

Triazines. Triazine compounds include simazine and atrazine. These are soil sterilants when applied at high rates. They are noncorrosive, nonflammable, and present no electrical or conductivity problem around utilities, powerplants, transformers, signal blocks, or other electrical installations.

Simazine, a standard stock item, is partically insoluble in water. It is formulated as an 80 percent water-dispersible powder and as a 4 percent granular product. Both formulations are used for the nonselective control of vegetation on areas where any plant growth is undesirable. The granular product is also effective against rooted aquatic plants such as coontail, fanwort, horned pond-weed, and water milfoil.

Simazine is absorbed by soil colloids. High cation-exchange capacity, high organic-matter content and, to a less extent, high clay content of soils reduce its toxicity to plants. It is probably also deactivated by soil micro-organisms. Simazine has little or no contact action on foliage, so there is no drift hazard. It cannot penetrate an unbroken leaf cuticle and is absorbed only through the roots. Simazine is ineffective until water carries it to the root zone, and its action is slow. It is easily removed from equipment by washing. It forms a suspension in water that requires agitation to keep the chemical from separating out.

Atrazine, a nonstandard stock item, is formulated as an 80 percent water-dispersible powder and a 4 percent granular product. It is more soluble than simazine, so it is more effective in dry areas. Weeds that are better controlled with atrazine than simazine are: horsetail; Indian hemp; lettuce, prickly; nutgrass, yellow; rush, sedge; and thistle, Canada.

Atrazine, unlike simazine, is absorbed through plant leaves; hence, there is a drift hazard. It is slightly more toxic than simazine to mammals and remains toxic in the soil for a slightly shorter time.

Exercises (410):

1. When applied at high rates, triazine compounds are used as _________________________ .

2. The triazine compound that has little or no contact action on foliage and does not penetrate unbroken leaf cuticles but is absorbed only through the roots is _________________ .

3. The triazine compound that is available as standard stock item within the Air Force is ____________ .

4. The triazine compound that presents a drift hazard is ____________ .

5. Based upon the text, ____________ would be the safest to use.

411. List the characteristics of dinitro compounds and the hazards presented to humans; and cite uses and availability of the dinitros.

Dinitros. These are contact herbicides used alone and to fortify oils. The parent compounds do not dissolve in water but are soluble in oil. Sodium, ammonium, or amine salt formulations are water soluble.

The three parent compounds are designated by the Weed Society of Amercia (WSA) as: DNAP, 4,6-dinitro-o-sec-amylphenol; DNBP, 4,6-dinitro-o-sec-butylphenol; and DNC, 3,5-dinitro-o-cresol.

All three compounds are yellow dyes that stain skin, hair, and clothing. They are highly poisonous if swallowed, if absorbed through the skin, or if any appreciable amount of spray mist is inhaled. Although they are not irritating, they are readily absorbed through the skin. They should be kept away from heat and open flame.

These compounds are nonstandard stock items within the Air Force inventory and are used sparingly at the present time by Air Force personnel.

The parent compounds are used nonselectively for top-kills of vegetation. The sodium, ammonium, amine salts are used selectively. The parent compounds are very effective contact herbicides that control a wide range of herbaceous plants, including many oil-resistant plants. They require large amounts of water, and their effectiveness as weed killers varies widely with the temperature.

The dinitros are not economical to use on perennial grasses and on coarse, vigorous, annual grasses. Repeated applications are required for control in areas of long seasons and high rainfall.

DNBP is the most effective form, DNC the least effective, and DNAP intermediate.

DNBP commercial formulations contain 5 pounds DNBP per gallon plus 87.9 percent oil or an alkanolamine salt containg 3 pounds DNBP per gallon. Ammonium salts of DNBP contain 1 pound per gallon.

DNAP commercial formulations contain 75 percent DNAP.

DNC commercial formulations contain 30 percent sodium salt of DNC. The effectiveness of DNC can be increased by adding ammonium sulfate, aluminum sulfate, or sodium bisulfate.

Exercises (411):

1. List the physical characteristics of the parent compounds of the dinitros.

2. List the hazards presented to humans by dinitro compounds.

3. Dinitro parent compounds are used as ____________ ____________ herbicides and are very effective for controlling ____________ plants.

4. The three parent compounds of the dinitros compounds are ____________ , ____________ , and ____________ .

5. Why are these compounds nonstandard stock items within the Air Force?

412. Point out characteristics, uses, availability, and safety precautions of anticoagulant compounds.

Anticoagulants. These are synthetic organic compounds that are used mostly as rodenticides, although at least one of these compounds is used in the medical treatment of humans in the prevention of blood clots.

Anticoagulant rodenticides act to reduce the clotting ability of the blood, resulting in internal and external hemorrhage and eventual death. An important characteristic is that relatively low dosages of anticoagulants ingested daily for approximately 7 days are fatal to rodents when the same total amount as a single dose may produce no significant damage or symptoms. The low concentrations at which the anticoagulant rodenticides are effective almost eliminates the hazard of acute toxicity to humans and greatly reduces this hazard to domestic animals. Also, the meal baits in which they are used are not generally attractive to children and pets.

The anticoagulants kill in a radically different manner form the older single-dose poisons. Most single does poisons kill rats within hours (½ hour to 48 hours) after ingestion. Anticoagulants must be ingested in small amounts for several days before they become effective. Even when weakened, rats apparently do not associate their loss of strength with their food supply. They return to feed on anticoagulant treated baits again and again. Thus, the problem of bait shyness commonly associated with "one shot" poisons is largely overcome. Nonfatal doses of single-dose poisons are painful; whereas, anticoagulants apparently cause no pain.

Warfarin is known by the chemical name -3(alpha-acetonyl-benzyl)-4-hydroxycoumarin, and its chemical formula is C19H16O4. It is also available as the water soluble sodium salt of this enol form called *warficide*. Warfarin concentrate for mixing with solid food baits was first released for public use in June 1950. It is a colorless and stable crystalline solid at ordinary temperatures and pressures. It is odorless, tasteless, and has a low solubility in water.

Warfarin is available as a 0.5 percent powder concentrate suitable for mixing with a bait such as cornmeal. The concentrate diluent is cornstarch. Ready-to-use dry bait mixes containing 0.025 percent warfarin are also available. The sodium salt of warfarin is sold as a 0.5 percent concentrate which is readily dissolved in sufficient water to make a final water bait concentration of 0.05 mg./ml.

It may be used in most situations for the control of rats and mice. The susceptibility of the various species of domestic and field rodents differs. In the interest of both economy and safety, the lowest bait concentration consistent with the most effective control should be used.

Thorough mixing of the bait and poison is of the utmost importance. A power mixer should be used when large quantities are mixed on a routine basis. It is important that clean mixing equipment be used to avoid contaminating the poisoned bait with materials which may reduce its acceptability to rats and mice. A small amount of activated charcoal, about ½ ounce to 20 pounds of bait mixture, may be added to discolor the bait mixture and prevent it from being mistaken for food. Equipment used in preparing poison baits must be thoroughly cleaned after its use.

In areas frequented by children or pets, bait should have a protective covering such as pipes, boards, and cans. They should be placed in areas where accidental spillage would not contaminate food and water of humans and desired animals.

Warfarin can kill any mammal or bird by causing hemorrhage if it is ingested in sufficient dosage over a period of days. When used in baits at concentrations as high as 0.025 percent, household pets must eat fairly large quantities of the poisoned bait over a period of days before fatal hemorrhage occurs. Data from animal experiments suggest that a single feeding of prepared bait by an animal would be harmless except to certain very susceptible animals, especially pregnant females. However, where children or pets are present, both food and water baits should be placed to minimize the possibility of accidental ingestion. Species differ greatly in susceptibility. For example, chickens may be raised to maturity on an adequate growing mash containing an effective rodenticidal concentration of warfarin.

Fumarin (trade name for cumafuryl) is another anticoagulant that was released for sale in the United States in June 1955 as a 0.5 percent concentrate to be diluted for use to 0.025 percent by adding 19 parts of bait (carrier) material to each part of concentrate by weight. The chemical name of cumafuryl is 3-(alphaacetonyl-furfuryl) -4-hydroxycoumarin. The concentrate is a white fluffy powder that is tasteless and odorless. The manufacturer of Fumarin recommends a cereal grain as the carrier and suggests that lower concentrations may be effective against certain species under ideal conditions. There is no apparent advantage to increasing the concentration over the 0.025 percent strength. Increased concentration might be less effective due to reduced bait acceptance.

The manufacturer recommends that baits *should not* be adulterated with other poisons or insecticides. To do so might create an acceptance problem.

Pival is a fluffy, yellow powder with a slightly moldy, acrid odor suggestive of marigolds or tobacco. It is essentially insoluble in water but soluble in organic solvents. The sodium salt derivative, though soluble in water up to 0.1 percent, nevertheless precipitates sufficiently from many natural waters to be observed grossly and to cause concern about diminished efficiency. To eliminate this drawback, a stabilizing agent, versene (regular), can be added to the water to make a 0.1 percent solution from which the pindone will not precipitate.

Pival is obtainable as a 0.5 percent concentrate in cornstarch. The manufacturer recommends a 1:19 dilution by weight in bait. The sodium salt (Pivalyn) is available as packaged units sufficient to poison 1 quart of water. Each packet has versene added to the Pivalyn.

Pival may be used in most situations for the control of rats and mice. It appears to be approximately equal to warfarin in its rodenticidal effectiveness. Pival has been found to inhibit mold formation and the development of insects infesting grain.

Diphacinone is one of the newer anticoagulant chemicals made available in the fall of 1957. This material is available as a 0.1 percent concentrate, which is mixed 1 pound to 19 pounds of bait, and in a ready-to-use dry bait formulation containing a 0.005 percent concentration of the active ingredient, 2-diphenylacetyl-1, 3-indandione. The manufacturer of this product called Diphacin claims that this material requires fewer successive feedings to kill than other anticoagulants and that it resists insects and mold. Methods of application for rodent control are similar to those used for other anticoagulants in food baits.

PMP (commercial name) is another one of the newer anticoagulants. Its chemical name is 2-isovaleryl-1, 3-indandione. PMP is available as a ready-to-use dry meal bait containing 0.055 percnet toxicant, in a 1.1 percent starch concentrate for use in food baits, in a water soluble bait, and for professional use only in a 2.18 percent tracking powder. A universal concentrate for use in either cereal or water baits is also available containing 4.33 percent PMP.

Food baits may be prepared from the starch concentrate containing one percent PMP. The manufacturer recommends the standard dilution rate of one part concentrate to 19 parts of bait material.

The water-soluble form is available in 1 $^2/_3$ ounce key opening cans, and the contents are added to 1 quart of water. The manufacturer emphasizes that "effective use requires continuous exposure over a period of 6 to 10 days or until rodent activity ceases."

Anticoagulants are available as standard stock items in the forms of universal concentrates and ready-mixed baits. Diphacin is available as a standard stock item in a bait block form.

Exercises 412:

1. Anticoagulant compounds are primarily used as ____________ but may be used in medical treatment of humans to prevent ____________ ____________.

2. Explain how anticoagulants kill.

3. Comparing anticoagulants with the older single dose type rodenticides, list the advantages of the anticoagulant compounds for the following:
    a. Safety to other animals and humans:
    b. Humane aspect:
    c. Acceptability:

4. The anticoagulant compound that is described as being a white fluffy powder that is tasteless and odorless in the concentrate form is ____________.

5. The anticoagulant compound that probably would be the best to use in damp, dark areas where molding may be a problem is ____________.

6. The anticoagulant compound that is described as being a colorless, odorless, tasteless, and stable crystalline solid at ordinary temperatures and pressures in the concentrate form is ____________.

7. The anticoagulant compound that is described as being a fluffy yellow powder with a slightly moldy acrid odor in the concentrate form is ____________.

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8. Of all the anticoagulants discussed in the text, the one that would most likely not be used in damp, dark areas due to its mold inhibiting characteristics is ____________.

9. What is the only anticoagulant rodenticide compound that is available in a bait block form as a standard stock item within the Air Force supply system?

10. From the safety standpoint, relatively low dosages of anticoagulants must be ingested daily for approximately how many days?

413. Identify characteristics, uses, availability, and safety precautions of various pesticidal compounds.

Other Pesticidal Compounds. The compounds that are discussed in this objective include flourines, thallium sulfate, zinc phosphide, synthetic pyrethroids, diquat, and mercury compounds.

Flourines. Only one of these compounds is available for use by military personnel in controlling pests, which is a synthetic organic element.

Sodium monofluoroacetate (Compound 1080) is a light, white, crystalline compound, odorless and tasteless, soluble in water, but practically insoluble in organic solvents, fats, and oils. Although this rodenticide is a nonstandard stock item, it is available for military use; but, because of its high toxicity to vertebrates, its use is restricted to the point of almost nonexistence and most be approved by the Surgeon General of the service involved.

There is no know antidote for 1080; therefore, every safety precaution must be taken to prevent inhalation and ingestion. Wear disposable gloves and dispose of them properly, wear a respirator designed to protect against this compound, and insure that the no smoking, no eating, and no drinking rule is strictly inforced while handling this compound.

Thallium sulfate. This is a synthetic inorganic compound that contains a bluish lead-like metal element and is greyish white in color, odorless and tasteless. It is a highly toxic stomach poison used primarily for controlling domestic and fiedl rodents. This compound is no longer available to Air Force personnel and it is practically impossible to obtain anywhere in the United States.

The only reason for mentioning this compound is to bring awareness to its toxicity and to make it known that it is not to be used. Because this compound has not been restricted for very long, it is possible that you might happen to find some of this compound pigeonholed in pest management sections. In case you do find this compound in a shop, you should arrange for disposal by following the guidelines established by AFM 67-1, Volume 6 or AFR 19-1.

Zinc phosphide. Zinc phosphide, a synthetic inorganic compound, is a heavy, dark gray powder that is chemically stable and insoluble in water. It has a faint odor of phosphorus due to the slow release of phosphine (PH3). Both the powder and gas are very toxic. Zinc phosphide should be weighed and mixed out-of-doors, preferable, or in a well-ventilated room, to avoid inhalation of gas or dust. Gloves should be worn when one is mixing or distributing baits.

This rodenticide has been used for many years and is effective against all species of rats and mice. Though highly toxic to all animal life, some animals will not eat baits prepared with it because of its objectionable odor and taste. Most species of rats and mice will accept attractive zinc phosphide baits. Zinc phosphide is used at a strenght of about one percent by weight in blended or mixed baits. The baits must be thoroughly mixed because of the small amount of toxicant required.

Zinc phosphide reacts with dilute acids to release phosphine; therefore, bait materials containing organic acids may be unsuitable because they cause this poison to deteriorate too rapidly. However, bait materials that cause slow deterioration may be desirable as a safety factor. This compound is a standard stock item within the Air Force inventory.

As a safety factor, tartar emetic (antimony potasium tartrate) should be added to the poison before mixing with bait in the proportion by weight: zinc phosphide, 8 parts; tartar emetic, 3 parts, even though acceptability of such baits is thereby reduced. Oils and fats used as a binder also increase absorption of poison into a rat's body.

Poisoned baits should be placed out of reach of other animals. Wear gloves when handling poison and poisoned baits. Use rubber gloves in mixing baits. Wash all utensils after mixing. Distribute bait with a spoon, and discard all unused bait safely. Be sure that each container is labeled "Poison" and placed out of reach of children, irresponsible person, pets, and livestock.

Synthetic pyrethroids. These are synthetically produced compounds that are used extensively as replacements for natural pyrethrum.

Allethrin is similar to the cinerin I found in pyrethrum. This insecticide was synthesized by workers of the US Department of Agriculture as a replacement of natural pyrethrum. Allethrin is usually fortified by synergists such as piperonyl butoxide or MGK 254. Field populations of flies and mosquitoes have not developed resistance to pyrethrum or allethrin.

Resmethrin (SBP-1382) is one of a group of synthetic pyrethroids made by modifying the structure of natural pyrethrins. It is more effective against some insect species than the natural pyrethrins, is even less hazardous to mammals, and does not require synergists to enhance its insecticidal action. In 1973, a commercial preparation containing resmethrin was sold in the United States to control insects in households and restaurants. This preparation includes ultraviolet light screening agent which helps prevent breakdown of the material, permitting residual insecticidal action for a long time, particularly in dark areas such as those behind stoves in kitchens.

Because pyrethroids do not persist a long time in the environment, much research is being conducted with these materials. They may eventually play a role in controlling adult mosquitoes and flies, including the stable fly.

These compounds are primarily used as aerosols for space spraying areas in the control of flying insects and are commonly received, instead of pyrethrum, through the Air Force supply system even though they are not listed as a standard stock item.

Diquat. This compound is a nonvolatile, nonflammable, and nonselective contact herbicide used for aquatic weed control. It is highly toxic to mammals when ingested, and special precautions must be taken to avoid inhalation and ingestion; however, it is a standard stock item.

Mercury. All mercury compounds are highly toxic and may be either inorganic or organic. Due to their high toxicity, there is only one mercuric compound that is used by the Air Force, and that is PMA.

PMA (Phenyl mercuric acetate) is a selective compound used as a postemergence herbicide. This compound has also been used as a fungicide in treating seeds and grains to prevent molding.

PMA is formulated as a water solution and as granules. These formulations can cause severe burns and irritations to the skin and eyes.

This is a highly toxic compound both orally and dermally, and extreme care must be taken to prevent ingestion, inhalation, and contact by wearing coveralls, gloves, hat, boots, respirator, and goggles.

Do not apply to turf if temperature is above 85° F (30° C), and avoid drift.

PMA is a nonstandard stock item but can be obtained through local purchase.

Exercises (413):

Match compounds with the statements that apply to each:

Compound	*Statement*
____ 1. Allethrin.	a. This compound is a heavy dark gray powder that has a faint odor of phosphorous and is used as a rodenticide when mixed with bait.
____ 2. Diquat.	
____ 3. PMA.	
____ 4. Resmethrin.	

Compound

____ 5. Sodium monofluoroacetate.

____ 6. Thallium sulfate.

____ 7. Zinc phosphide.

Statement

b. This compound is used as a space spray for controlling flying insects and does not require a synergist to enhance its insecticidal action.

c. This compound is used as a nonselective contact herbicide for controlling some species of aquatic weeds and is highly toxic to mammals when ingested.

d. This compound is a light, white crystalline compound that is odorless, tasteless, highly toxic, and is soluble in water and is used as a rodenticide water bait upon approval by the Service Surgeon General.

e. This compound is one of several compounds that was synthesized as a replacement of natural pyrethrum and is normally fortified by a synergist.

f. This is a highly toxic compound both orally and dermally, and is formulated as a water solution and as granules. Formulations of this compound can cause severe burns and irritations to the skin and eyes and should not be applied to turf when temperatures are above 85° F.

g. This compound is no longer available to Air Force personnel and is practically impossible to obtain within the United States. It is a synthetic inorganic compound that is greyish white is color and is odorless and tasteless.

Complete exercises 8 through 11.

8. The compound that is often referred to as Compound 1080 is ______________ .

9. Of all compounds discussed thus far, the one that has no known effective antidote is ______________ ______________ .

10. The compound that must be disposed of upon detection due to its use being extremely limited and cannot be used by Air Force personnel is ______________ .

11. The substance that is added to zinc phosphide as a safety factor is ______________ .

414. State the characteristics, uses, availability, and safety precautions for each identified fumigant compound.

Compounds Used as Fumigants. Fumigants are gases designed to kill cells and tissues of plant and animal matter by penetrating the dermal wall and respiratory process. These gases are dispersed in molecular form which provides thorough and rapid penetration. Fumigants may be obtained in solid, liquid, and gaseous forms. Regardless of what form the fumigant is obtained in, the end result will be in gaseous form once it is released.

All modern fumigants that produce effective control of pests are also toxic to man. Therefore, every fumigator must receive thorough training, must be provided with proper equipment, and must understand the hazards associated with the fumigants he uses.

Naphthalene. This common household fumigant is obtained by the distilling of coal tar. The product is marketed as moth balls or flakes and is used by the Air force in controlling bats. Naphthalene has proven to be an excellent repellent for squirrels, skunks, and rats in inclosed spaces. It has been replaced, to a large extent, by paradichlorobenzene, a fumigant that has a more pleasant odor. Naphthalene flakes are available as a nonstandard stock item.

Paradichlorobenzene (PDB). This is a chlorinated hydro-carbon compound and is used primarily for protecting woolens, furs, and insect collections from insect attack, and as a masking deodorant in such places as public restrooms. Satisfactory control of fly breeding in garbage cans is maintained by applying two ounces of PDB per can every 1 to 2 weeks in a container attached to the cover. Paradichlorobenzene is a nonstandard stock item.

Dichlorvos. This compound was previously discussed in this section under the subject of organophosphates. It does serve as a fumigant and is authorized for use by the Air Force when placed within retrograde cargo.

Calcium cyanide. This compound is probably the most commonly used rodent fumigant for gassing rodent burrows outdoors or small inclosed harborages indoors. Calcium cyanide *should never be used near a building occupied by people*. It is a grayish-white compound available in either granular or powdered form which produces hydrocyanic acid gas upon exposure to moist air. Both the dust and the gas liberated will kill any animal, including insects and man. In rat control it is used to treat burrows and under certain circumstances small inclosed spaces or harborages. An advantage of this gas over poisons is that it kills the flea and mite parasites as well, a factor of considerable importance in controlling the spread of diseases such as plague and murine typhus.

Calcium cyanide is extremely hazardous to humans and should be used only be well-trained personnel. Personnel should stand upwind while applying this fumigant and must have appropriate gas masks and cannisters available for use. Calcium dust is available as a standard stock item.

Aluminum phosphide. This compound is one of the newest compounds used as a fumigant. The fumigant is actually hydrogen phosphide which is a gas released by aluminum phosphide. It is used primarily for intransit freight car fumigation to rid processed nonperishable subsistence items of stored products pests. This compound can be obtained in pellet, tablet, and powdered forms and is a standard stock item authorized for use by military personnel in fumigating for stored products pests which is accomplished by the inplace atmosphere fumigation method.

Aluminum phosphide has a very rapid molecular action, is corrosive to gold, and, in its pure state, is highly explosive when exposed to the atmosphere; but the forms in which it is obtained for Air Force use have been formulated with a cooling agent and protective layer to retard rapid decomposition caused by exposure to the atmosphere.

Although this compound is considered to be the safest fumigant available, protective clothing and equipment still must be worn when entering or cleaning a freight car of stack that is under fumigation. The advantages of this fumigant is the intransit fumigation ability and the fact that stacks can be fumigated under cover within a building that is occupied by other personnel.

SMDC (Vapam). This is a solid compound that is readily soluble in water and is recognized as a fumigant for controlling vegetation. Its use in the Air Force is limited, but it can be used as a preplant fumigant to kill germinating seed of both grasses and nongrasses. It is sometimes used in controlling nematodes and soil fungi and is a nonstandard stock item.

Sulfuryl fluoride. This fumigant is a nonstandard stock item, but is authorized for use by Air Force personnel in fumigating structures for dry wood termites. This is a liquid compound that is stable, odorless, nonflammable, nonexplosive, noncorrosive, and shows rapid penetration and may eventually replace methyl bromide.

Methyl bromide. This is a heavy (heavier than air), odorless, and nonflammable gas fumigant. It is a standard stock item and is authorized for use within the Air Force for fumigating structures in treating for dry wood termites. Other methyl bromide uses include fumigating for clothes moths and carpet beetles and also as a herbicide fumigant.

As a herbicide fumigant, it is used as a preplant herbicide to kill seeds and can be used to control nematodes and soil fungi. It is especially good as a herbicide fumigant because of its heavy properties which allows it to remain on the ground instead of rising.

Since methyl bromide is odorless, chloropicrin is added to provide a warning agent.

All fumigants are toxic to all forms of life, and their use must be with extreme caution. Applicator must wear protective clothing and equipment. Gas masks with appropriate cannisters for the type of fumigant being used must be worn and precautions must be taken to avoid explosions and fires. The area being fumigated must be adequately and readily identified with the posting of warning signs, and in most cases the areas must be sealed off to keep individuals away.

Detailed safety precautions for using all types of pesticides are provided in Volume 2.

Exercises (414):

State the characteristics, uses, availability, and safety precautions for each of the fumigants identified below.

1. Methyl bromide:
   a. Characteristics
      (1)
      (2)
      (3)
      (4)
   b. Uses:
      (1)
      (2)
   c. Availability:
   d. Safety precautions:
      (1) Personal protection
      (2) Property protection
      (3) Public protection
2. Aluminum phosphide:
   a. Characteristics:
      (1)
      (2)

b. Uses:

c. Availability:

d. Safety precautions for:
   (1) Personal protection

   (2) Property protection

   (3) Public protection

3. Calcium cyanide:
   a. Characteristics:
      (1)

      (2)

      (3)

   b. Uses:

   c. Availability:

   d. Safety precautions for:
      (1) Personal protection

      (2) Public protection

1-2. Pesticide Formulations and Calculations

In most cases, pesticides are received in concentrated form to save expenses for transporting. Therefore, you as a pest manager, will be required to prepare pesticidal formulations that will be effective and safe from the pesticidal concentrates. To do this, you must know what type of materials that can be used in preparing a certain type of formulation. In addition to this, you must be capable of calculating the correct amount of concentrate to be used in obtaining and identified percent of finished product and calculating the correct amount of finished product to do the job according to recommendations provided on the pesticide label.

To calculate the amount of finished product needed to do a job, you must also be able to calculate the amount of areas to be treated and, in many cases, the speed in which the pesticide has to be applied in order to apply it at the recommended rate.

Within this section, discussion will be based upon the identification of supplementary materials used in conjunction with pesticides, the components of common pesticide formulations, the methods for calculating the amount of area, rate of application, and the quantity of pesticide concentrate to be added to obtain a proper mixture.

NOTE: All calculation exercises in this chapter have been carried two places beyond the decimal point to obtain a more accurate product which is required when pesticides are involved.

415. Match supplementary materials with their appropriate purpose of use in conjunction with pesticides.

Supplementary Materials and Their Use. The materials used in the context of this course are materials that help the pesticides to work more efficiently and economically by acting as solvents, emulsifiers, spreading and wetting agents, adhesives or stickers, perfumes and masking agents, synergists, and carriers or diluents. It is generally not economical to apply pesticides as technical grade material or in concentrated form. A wide variety of chemicals have been found useful in formulating sprays and dusts.

Repellents. These are substances that keep pests away from plants or animals by emitting odors that are offensive or present an appearance or taste that is undesirable. Diethyl toluamide, a repellent, is applied to exposed skin surfaces and clothing to prevent attack by mosquitoes and other arthropods. Moths are repelled by clothing treated with naphthalene. Repellents do not necessarily kill arthropods, but they do protect people and materials from arthropod attack.

Attractants. These are substances that attract arthropods by sensory stimulation. They are used to lure arthropods into traps or away from certain areas. They are also used to enhance poison baits so that an arthropod will eat it. An example of attraction is the response of insects to odors from foods, opposite sex, prey, or from sites suitable for the deposit of eggs. A few attempts have been made to use the principle of attraction to induce pests to eat poison baits or to lure them into various types of traps.

Dessicants. Very finely powdered silica gels and silica aerogels have been tested for the control of cockroaches, fleas, kissing bugs, dry wood termites, and such ectoparasites of domestic animals as ticks, lice, and mites. Silica aerogels and diatomaceous earths are also used to protect stored grains from the attacks of beetles and moths in many countries. These compounds kill arthropods by damaging the outer, waterproof layer of the arthropod exoskeleton, the epicuticle,—either by absorbing the fatty or waxy material—or by abrasion. The arthropods lose liquid rapidly, sometimes becoming incapacitated in an hour's time, and die by dessication. These materials are reported to be nontoxic to man and to warm-blooded animals. Sorptive dusts are amorphous rather than crystalline compounds, so they do not cause silicosis. Since the action of the dusts is physical rather than chemical, it is possible that arthropods will not become resistant to them. The real problem is using this type of control is to keep the fine powder in areas where arthropods will come in contact with it.

Solvents. A solvent dissolves a pesticide so that the molecules of a pesticide are evenly dispersed throughout the resultant solution. The solvent acts both as a carrier for the pesticide and as a diluent, reducing the concentration of the insecticide to the most economical percentage. Some solvents, such as petroleum fractions, also add to the insect-killing powers of the formulation. Many pesticides are dissolved in solvents such as fuel oil, kerosene, or xylene in the preparation of field spray solutions or emulsifiable concentrates. The selection of a solvent depends on its ability to hold the pesticide in solution, its toxicity to animal and plant life, its odor and staining characteristics, and its fire hazard.

Two general types of solvents are commonly used: (1) volatile liquids, such as xylene, which evaporate after spraying and leave only a residual deposit of the pesticide, and (2) nonvolatile or semivolatile liquids, such as petroleum oil, which leave the surface coated with a solution of the toxicant. Fuel oil and kerosene do not dissolve the high concentrations of pesticides needed to make emulsifiable concentrates, so other compounds are often used as auxiliary solvents. The flashpoint must be considered when selecting a pesticidal solvent for fogging operations. Materials with a low flashpoint increase the fire hazard of an insecticide; therefore, solvents with flashpoints over 200° F are preferred.

Emulsifiers. An emulsifier is a surface active agent (detergent) that stabilizes a mixture of a liquid within a liquid. Milk, for example, is an emulsion with tiny globules of butterfat and other ingredients suspended in water. A technical grade insecticide may be dissolved in xylene and an emulsifier added to produce an emulsifiable concentrate of low bulk that may be stored and moved with ease, rather than storing or shipping large amounts of more dilute materials. At the time of use, the concentrate is diluted with water, the most universal and economical carrier, to produce and inexpensive and effective emulsion.

The emulsifier forms a thin film around each minute droplet of oil, resisting the tendency of the droplets to coalesce and separate into continuous layers of oil and water. In the familiar oil-in-water insecticidal emulsions, the many finely divided oil droplets form the dispersed phase and the water comprises the continuous phase.

The early emulsifiers were soaps, but modern usage requires more effective synthetic detergents such as the Tritons, Spans, and Tweens. Substances that lower the surface tension of water tend to stabilize a water emulsion.

Spreading and wetting agents. Many of the synthetic emulsifiers and detergents are used also as wetting and spreading agents. These agents are rather difficult to define except according to the manner in which they are used. Detergents are developed primarily for their cleaning ability. Spreading agents, such as Hercules Triton B–1956, may be added to oil larvicides to decrease the surface in which the larvae live. Wetting agents promote the formation of a continuous film of pesticide on water-repellent surfaces or incrase the rate with which the pesticide soaks into or wets other materials. Sulfonated oils, the higher sodium alkyl sulfates, and other surface-active dispersants may be added to pesticidal dusts to produce wettable pesticide powders (also known as water-dispersible powders) which form suspensions when added to water.

Adhesives or stickers. Adhesives are substances added to liquid sprays to improve the adhesive quality of the insecticidal deposit, especially to avoid leaching by the rain. Protective materials such as gelatin, glue, rosin, and other gums are valuable adhesives.

Masking agents. Perfumes or masking agents are agreeable scents, like oil of wintergreen, that are added to household insecticides to mask unpleasant odors such as those of kerosene, pyrethrum, or cyclohexanone. There are many proprietary perfumes and masking agents now available.

Synergists. Synergism (from the Greek, meaning "working together") is said to occur when two materials give greater physiological action when applied together than separately. Certain compounds added to pesticidal mixtures do increase their toxicity; therefore, the amount of the basic pesticide in the formulation may be greatly reduced. For example, the addition of the relatively inexpensive synergist piperonyl butoxide to fly and mosquito sprays makes it possible to reduce the amount of the more expensive pyrethrum insecticide and still obtain effective control with substantial savings in the final formulation. These synergists may also be used to counteract the resistance of insects to certain chemicals. A synergist apparently brings about an alteration in the insect's physiological reaction to an insecticide, making the poison more effective. A synergist applied as much as a day before the pesticide may still produce an activating effect. However, a synergist applied after the pesticide is of no value. The most practicable procedure is to mix the synergist with the insecticide; then, only one application is required.

Some of the activators, or synergists, are piperonyl butoxide, sesamex, sulfoxide, propylisome, and MGK-264.

Carriers and diluents. Most pesticidal dusts are purchased ready for use, but may be diluted for special purposes. Some of the generally available carriers include attapulgite, bentonite, calcite, diatomite, gypsum, hydrated lime, kaolin clay, pyrophyllite, and talc. Dust carriers should be relatively low in cost, and must have great absorptive capacity when they are used to absorb liquid pesticides such as malathion. These carriers must not produce any breakdown of the pesticidal chemical. Dusts are usually mixed in a ball-mill or other type of blending machine. They must be extremely fine particles and of low density in order that they may be airborne for a considerable distance when applied.

Exercises (415):
Match each of the supplementary materials with the purpose of use.

Purpose of Use	*Supplementary Materials*
____ 1. Adhesives stickers.	a. Peanut butter, apples, and sugar.
____ 2. Attractants.	b. Xylene, fuel oil, and kerosene.
____ 3. Carriers diluents.	c. Oil of wintergreen, and shaving lotion.
____ 4. Dessicants.	d. Bentonite, vermiculite, and talc.
____ 5. Emulsifiers.	e. Gelatin, and resin.
____ 6. Masking agents.	f. Silica gels.
____ 7. Repellents.	g. Naphthalene and paradichlorobenzene.
____ 8. Solvents.	h. Synthetic detergents.
____ 9. Spreading and wetting agents.	i. Piperonyl butoxide, and sesamex.
___ 10. Synergists.	

416. Match the formulation components with the appropriate pesticidal formulation.

Pesticide Formulations and Their Components. Pesticides are produced from natural or synthetic chemicals that kill insects readily, but will not cause undue hazards to man, animals, and plants when formulated and applied correctly. Precise formulation and application are essential in all pesticidal programs. Some toxicants are applied as technical grade pesticides, such as malathion or naled in ultra-low volume applications. Most pesticides, however, are made into proper strength dusts, granules, suspensions, solutions, or emulsions before application. Dusts are often diluted to lower concentrations with talc or pyrophyllite. Wettable powders are mixed with water to form suspensions of desired concentration. Liquid sprays are often purchased as concentrated solutions or emulsifiable concentrates. Concentrated solutions may be diluted with oils, and emulsifiable concentrates with water, to prepare field strength solutions or emulsions.

Technical grade pesticide. This is the basic toxic agent in its purest commercial form. It is rarely chemically pure. Some technical grade pesticides are liquids; others occur in solid form. Technical grade malathion is a clear amber liquid, whereas chlorpyrifos (Dursban) is a white, granular, crystalline material. Some undiluted technical grade pesticides are used in ultra-low volume space applications. However, in most cases, technical grade pesticides are mixed with a carrier before use, forming a dust, granule, suspension, solution, or emulsion as shown in figure 1-1 (components of basically dry formulations) and figure 1-2 (components of liquid formulations).

Pesticidal dusts. A pesticidal dust in its simplest form is merely finely pulverized insecticide such as sulfur dust used to repel chiggers. Most pesticidal dusts, however, consist of the *technical grade pesticide* and an *inert carrier*, figure 1-1, such as talc or pyrophyllite, with each minute particle of the carrier coated with the chemical toxic to insects. Dusts may be applied by hand, by simple dust guns, by large power dusters, or by airplanes. These materials are usually low in cost, easy to apply, nonstaining, and nontoxic to vegetation.

Pesticides in dust form are generally absorbed through the skin, but may be dangerous if inhaled into the respiratory tract. Dusts do not adhere well to vertical surfaces and are easily removed by rain and wind. They are unslightly in the home and have been replaced, for the most part, by sprays and aerosols.

Pesticidal granules. These are basically the same as a dust formulation as shown in figure 1-1, except the carrier particles are larger. Vermiculite is used as the inert carrier instead of talc or pyrophyllite in most granular formulations. Since granules are heavier than dusts, they do not adhere to leaves; therefore, they will penetrate dense foliage, which are real advantages where it is desirable for the pesticide to reach the water surface for mosquito control in vegetated swamps, or to get to the ground surface through trees and shrubs for chigger or fire ant control. Other advantages of using granules are that they provide longer lasting effects and they are not as apt to drift away from the target areas, as for an example of granules being used as herbicides.

Wettable powders. This formulation consists of the *technical grade pesticide* an *inert carrier*, and a *wetting agent* (usually a synthetic detergent) which facilitates mixing it with *water*. This is illustrated in figure 1-1. Many wettable powders contain an anticaking agent, which prevents lumping while in storage, and a dispersant which helps keep the particles in suspensions from settling out too quickly. Wettable powders may have a technical grade chemical content ranging from 15 to 90 percent. The insecticide is coated (absorbed) onto a fine inert dust, such as talc or pyrophyllite. Wettable powders have advantages over other concentrates. They do not require the addition of solvents which can cause injury to plants, they lack a solvent odor, and they do not have a tendency to

TECHNICAL GRADE PESTICIDE	+ INERT CARRIER	= INSECTICIDAL DUST or GRANULAR PESTICIDE		
	+ INERT CARRIER	+ WETTING AGENT	= WETTABLE (Dispersible) POWER	
	+ INERT CARRIER	+ WETTING AGENT	+ WATER	SUSPENSION

CFN-005

Figure 1-1. Components of basically dry formulation.

irritate the skin of the operators or to be absorbed through the skin.

Pesticidal suspensions. This formulation, as shown in figure 1-1, is obtained when *wettable powders* are added to *water*. A great advantage of a suspension is the tendency of the pesticide to be deposited on the porous surface of the structure sprayed. When porous materials such as concrete, plaster, adobe, or unpainted wood are sprayed with a suspension, the water penetrates, leaving the carrier and the maximum amount of the pesticide on the surface avaliable to kill pests. By contrast, when solutions or emulsions are sprayed, they penetrate porous materials so that less of the pesticide remains on the surface. During use, suspensions should be agitated continuously or frequently to prevent settling of the solid pesticide particles.

Suspensions tend to clog the strainers and nozzles of sprayers, especially when the wettable powder is stored for long periods in humid areas, which causes a clumping of particles, or when it is applied in high concentration. Trouble is experienced when using some municipal water supplies. Some waters produce foaming while others require the addition of more wetting agent.

Pesticidal solutions. This formulation, figure 1-2, consists of the *technical grade pesticide* dissolved in a *solvent* such as kerosene, diesel oil, or xylene. Solutions are available as ready-to-use formulations (such as the ordinary household fly and mosquito sprays with a low percentage of pesticide) and as solution concentrates. Solution concentrates contain a high percentage of insecticide and must ordinarily be diluted in oil, water, or other suitable solvent and diluent, indicated on the label, before use. Some concentrates are used without dilution in ultra-low volume (ULV) applications. In residual spraying, the solvent evaporates from the treated surfaces, leaving a deposit of the pesticide. DDT and some other insecticides cause a "blooming" of fine crystals that are readily picked up by the feet and bodies of insects. Some other pesticidesd, such as chlordane and malathion, do not crystallize; thus form a thin film of insecticide on treated surfaces.

Solution concentrates have the advantage of low volume, which reduces bulk, weight, and shipment costs. They are diluted at the destination, often in the field, making their portability a real advantage. The diluted mixture is termed "field strength solution." Oil solutions are used extensively in fog applicators, but are unsatisfactory for most dilute spray applications because of their toxicity to plants unless they are being used for the purpose of vegetation control.

Emulsifiable concentrates. Emulsifiable concentrates, figure 1-2, consist of the *technical grade pesticide*, a *solvent*, and an *emulsifying agent*, usually a synthetic detergent. Emulsifiable concentrates have the same advantages as the solution concentrates, plus

TECHNICAL GRADE PESTICIDE	+ SOLVENT	= SOLUTION		
	+ SOLVENT	+ EMULSIFIER	= EMULSIFIABLE CONCENTRATE	
	+ SOLVENT	+ EMULSIFIER	+ WATER	= EMULSION

Figure 1-2. Components of liquid formulations.

the benefits of a low cost and a readily available diluent water.

Pesticidal emulsions. When the *emulsifiable concentrate* is added to *water* and agitated, an *emulsion* is formed, figure 1-2, and the concentration of pesticide is reduced to the desired field strength. Pesticidal solutions and emulsifiable concentrates usually are clear, whereas emulsions have an appearance similar to milk, the most common natural emulsion. Unlike solutions, most pesticidal require periodic agitation to prevent the concentrate from separating out of the water. Emulsions or solutions, diluted to field strength, are called finished sprays.

Emulsions are widely used for the residual treatment of solid surfaces. Pests that rest on these treated surfaces are killed by the residue of pesticide. Some emulsions remain effective for a longer time on masonite and bare or painted wood than on glazed tile or shiny metal. This is an important consideration in determining the time interval between residual applications. Emulsions with a high percentage of the pesticide (and solvent) may *burn* plants. Therefore, any emulsions sprayed on plants should have a low percentage of pesticide and solvent and a high percentage of water. Mosquito larvicidal treatments with emulsions are usually confined to shallow bodies of water and to treatment of water containers, where excessive dilution will not take place. Oil solutions are more suitable for deep bodies of water. Mosquito larvicidal treatments with emulsions are usually in a thin film that kills the larvae when they come to the sprayed surface to breathe atmospheric air. Emulsions may damage aluminum, varnish, and painted surfaces, due to the action of solvents such as xylene. Emulsions are often corrosive to metal sprayers and their fittings. Sprayers used to dispense emulsions should be made of stainless steel, aluminum, fiberglass, or other noncorrosive materials. After use, the sprayers are easily cleaned by a water rinse.

Invert emulsions. These formulations are water-in-oil mixtures in which every droplet is surrounded by oil instead of water. This results in a viscous material that is difficult to apply but is less likely to drift. This type of formulation is used very seldom by the Air Force, but it does have certain merits in herbicidal applications.

Exercises (416):
Match the formulation components with the appropriate pesticidal formulation.

Pesticidal Formulation

____ 1. Emulsifiable concentrates.
____ 2. Invert emulsions.
____ 3. Pesticidal dusts.
____ 4. Pesticidal emulsions.
____ 5. Pesticidal granules.
____ 6. Pesticidal solutions.
____ 7. Pesticidal suspensions.
____ 8. Technical grade pesticide.
____ 9. Wettable powders.

Formulation Components

a. Technical grade pesticide and vermiculite.
b. Technical grade pesticide, talc, and synthetic detergent.
c. Technical grade pesticide, xylene, synthetic detergent, and water.
d. Purest commercial toxicant.
e. Technical grade pesticide, pyrophllite, synthetic detergent, and water.
f. Technical grade pesticide, and kerosene.
g. Technical grade insecticide, kerosene, and water.
h. Technical grade pesticide and pyrophyllite.
i. Technical grade pesticide, xylene, and synthetic detergent.

417. Solve given area calculation problems.

Area Calculations. In order to apply pesticides in accordance with pesticide label specifications, you must first determine the amount of area to be treated. Pesticide labels will specify that a certain amount of the pesticide must be applied over a specific number of square feet, linear feet, cubic feet, or acres. Therefore, when you are required to treat a designated facility or area, you must know exactly how many square feet, linear feet, cubic feet, or acres are involved.

This objective will enable you to obtain this information so that you can prepare and apply the exact amount of pesticide required at the rate specified.

Table 1-1, Table of Equivalents, is provided for your information and reference, as required, in the remaining portions of this course.

Square foot formula for rectangles. Determining the square feet is required when the pesticide label specifies a certain quantity of pesticide to be applied per square foot, thousand square feet, or other. This term usually applies to a rectangular area such as walls, ceilings, floors, and/or a plot of ground.

(Square foot formula for rectangles):

$$X = W \times L$$

Where:

X = total square feet within an area
W = width of area
L = length of area

Example: Determine the total square feet contained in an area that is 20 feet wide and 40 feet long:

$X = W \times L$
$X = 20 \times 40$
$X = 800$ sq ft

NOTE: There are times when some pesticide labels refer to *linear foot* application of pesticides. When this term is observed, it is in reference to the actual distance (in feet) from one point to another. The width is not important in this case, because it has already been considered with the type of equipment designated to be used.

TABLE 1-1

TABLES OF EQUIVALENTS

Weight:

1 ounce (oz) (avoirdupois)	= 28.3495 grams
1 pound (lb) (avoirdupois)	= 16 ounces = 453.50 grams
1 ton (US short)	= 2,000 pounds = 907.185 kilograms = 0.893 tons (US long)
1 ton (US long)	= 2,240 pounds = 1,016.047 kilograms = 1.12 tons (US short)
1 gamma	= 1 microgram = 0.001 milligram
1 milligram	= 1,000 gammas = 0.001 gram
1 gram (gm)	= 1,000 milligrams
1 kilogram (kg)	= 1,000 grams = 2.205 pounds (avoirdupois)
1 ton (metric)	= 1,000 kilograms = 2,205 pounds = 0.984 tons (US long) = 1.102 tons (US short)

Volume or Capacity Measure (Liquid):

1 fluid ounce (US)	= 29.57 milliliters
1 pint (pt)	= 16 fluid ounces
1 quart (qt) (US)	= 2 pints = 0.9463 liter
1 gallon (gal) (US)	= 4 quarts = 0.8327 gallon (Imperial or British) = 231 cubic inches = 0.1337 cubic foot = 3.785 liters
1 gallon (Brit)	= 1.2009 gallons (US) = 4.546 liters
1 liter	= 1,000 milliliters = 1.057 quarts

At all temperatures up to 100°F, one gallon water weighs approximately 8.3 pounds, and one gallon of kerosene weighs approximately 6.8 pounds.

Volume or Capacity Measure (Dry):

1 quart (US)	= 2 pints = 1.1012 liters
1 bushel (bu) US)	= 32 quarts = 4 pecks = 1.244 cubic feet = 0.969 British bushel
1 bushel (Brit)	= 1.2843 cubic feet = 36.368 liters = 1.032 US bushel
1 liter	= 0.9081 dry quart (US)

Volume or Capacity Measure (Cubic):

1 cubic inch	= 16.387 cubic centimeters
1 cubic foot	= 1,728 cubic inches = 29.922 US liquid quarts = 7.481 US liquid gallons = 25.714 US dry quarts = 0.80357 US bushels = 28.316 liters
1 cubic yard	= 27 cubic feet = 0.7646 cubic meter
1 cubic millimeter	= 0.001 cubic centimeter
1 cubic centimeter	= 0.061 cubic inch

Linear Measure (Length):

1 inch (in)	= 2.54 centimeters = 25.4 millimeters
1 foot (ft)	= 12 inches = 30.5 centimeters = 0.3048 meter
1 yard (yd)	= 3 feet = 0.9144 meter
1 rod (rd)	= 5.5 yards = 16.5 feet = 5.029 meters
1 mile (mi)	= 320 rods = 1,760 yards = 5,280 feet = 1.6094 kilometers
1 micron ( )	= 0.001 millimeter
1 millimeter	= 0.0394 inch
1 centimeter	= 10 millimeters = 0.394 inch
1 meter	= 100 centimeters = 3.28 feet = 39.37 inches
1 kilometer	= 1,000 meters = 0.6214 mile

Square Measure (Area):

1 square foot	= 144 square inches = 0.0929 square meter
1 square yard	= 9 square feet = 0.8361 square meter
1 square rod	= 272.25 square feet = 30.25 square yards = 25.293 square meters
1 acre	= 43,560 square feet = 4,840 square yards = 160 square rods = 0.4047 hectare
1 square mile	= 640 acres = 259 hectares
1 square meter	= 1,550 square inches = 1.196 square yards = 10.76 square feet
1 hectare	= 2.471 acres = 10,000 square meters

0-049

Square foot formula for triangles. This formula is rarely required in pest management programs, but it may be needed for some areas that are more of a triangular shape than rectangular. This would allow more accuracy in determining the total square feet than figuring on the rectangular basis.

(Square foot formula for triangles):

$X = B \times P \times .5$

Where:

X = total square feet within an area
W = base of area
P = point of area
.5 = constant

Example: Determine the total square feet contained in a triangular area that has a 30-foot base and a 50-foot point:

$X = B \times P \times .5 \qquad X = 30 \times 50 \times .5$

$X = 750.0$ or 750 sq. ft.

Square foot formula for circles. This formula is rarely used. However, it may be used more frequently than the square foot formula for triangles. Some circumstances that might require the use of this formula include the required treatment of modern structures of circular design and the treatment of ground areas surrounding flag poles.

(Square foot formula for circles):

$X = \pi R2$

Where:

X = total square feet within an area
π = Constant (3.14)
R2 = Radius of circle (squared)

Example: Determine the total square feet within a circle that has a radius of 35 feet.

$X = \pi R2 \qquad X = 3.14 \times 35 \times 35$

$X = 3,846.50$ or 3,846 and 1/2 sq. ft.

Cubic foot formula. This formula is used in determining the total volume contained in an inclosed area such as a room, an entire building, or possibly a stack of commodities to be fumigated under cover. As previously stated, this formula is usually required when space sprays or fumigants are to be used.

(Cubic foot formula):

$X = W \times L \times H$

Where:

X = total cubic feet within an area
W = width of area
L = length of area
H = height of area

Example: Determine the total cubic feet contained within an area that is 40 feet wide, 60 feet long, and 8 feet high:

$X = W \times l \times H \qquad X = 40 \times 60 \times 8 \qquad X = 19{,}200$ cu. ft.

Exercises (417):

Solve each of the area calculation problems (to the nearest hundredths) that are provided below:

1. The total square feet contained in a triangular area that has a 100-foot point and a 60-foot base is ____________ .

2. The total square feet contained in a circle that has a radius of 50 feet is ____________ .

3. The total square feet contained in a rectangular area that is 5 feet wide and 70 feet long is ____________ .

4. A warehouse measuring [illegible] eet long, 30 feet wide, and 18 feet high would [illegible] tain ______ cubic feet.

418. Solve given capacity calculation problems.

Capacity Calculations. Although the capacity of most items of equipment used in dispersing pesticides has already been determined and properly identified, there could be situations that would require you to determine the capacity of a sprayer tank or other container that is to be used for formulating and transporting liquid pesticides.

Following the completion of this objective, you will be able to calculate the capacity, in gallons, of cylindrical, elliptical, and rectangular containers.

Formula for calculating the capacity of cylindrical containers. This formula can be used in determining the number of gallons or ounces that any given cylindrical container can hold.

NOTE: All measurements must be in inches.

(Formula for cylindrical containers):

$X = L \times D2 \times 0.0034$

Where:

X = capacity in gallons
L = length of container
D2 = diameter of container (squared)
0.0034 = constant

Example: Determine the capacity, in gallons, of a cylindrical container that is 6 feet (72 inches) long and 4 feet (48 inches) in diameter.

$X = L \times D2 \times 0.0034$ $\quad X = 6 \times 4 \times 4 \times 0.0034$

$X = 72 \times 48 \times 0.0034$ $\quad X = 564.01$ gallons

Formula for claculating the capacity of rectangular containers. This formula will be useful in determining the number of gallons or ounces that any given rectangular container can hold.

NOTE: All measurements must be in inches.

(Formula for rectangular containers):

$$X = L \times W \times D \times 0.004329$$

Where:

X = capacity in gallons
L = length of container
W = width of container
D = depth of container
0.004329 = constant

Example: Determine the capacity, in gallons, of a rectangular container that is 5 feet 60 inches long, 3 feet (36 inches) wide, and 3 feet (36 inches) deep.

$X = L \times W \times D \times 0.004329$ $\quad X = 5 \times 3 \times 3 \times 0.004329$

$X = 60 \times 36 \times 36 \times 0.004329$

$X = 336.62$ gallons

Exercises (418):

Solve each of the capacity calculation problems (to the nearest hundredths) provided below:

1. You have had a new rectangular container fabricated by the metal fabrication section on base which is to be used as a pesticide container. You are now faced with the problem of determining the capacity of the container so you will know how many gallons of pesticide it will hold. If the dimensions of the container measures 4 feet long, 3 feet wide and $1^1/_2$ feet deep, the capacity of the container will be ________ gallons.

2. The capacity of a cylindrical container that measures 4 feet long and 3 feet in diameter will be ____________ gallons.

419. Solve given rates of application calculation problems.

Calculations for Rates of Application. Information pertaining to the rate of application for a specific pesticide is provided on the pesticide label; however, this information varies with the type of pesticide being used. Rates of application for liquid insecticide may be given in gallons of finished spray per thousand square feet, gallons of finished spray per acre, pounds of active ingredient (AI) per thousand square feet, or pounds of active ingredient per acre. Most pesticidal dust and granule formulation application rates are given in pounds of diluent or active ingredient per acre.

Rates of application for many herbicides are given in ounces or pounds of acid equivalent (AE) per square foot, rod, or acre.

When applying space sprays and fumigants, the rate of application will normally be given in gallons, ounces, or pounds per thousand cubic feet.

It is very seldom that you will be treating an exact amount of area that is identified on the pesticide label. Therefore, you will be required to determine the exact amount of area to be treated and convert this total area into common usable figures in order to determine the exact amount of pesticide to be applied, and in some situations, the speed in which it must be applied.

Linear application formulas. When pesticide labels specify that a certain quantity of pesticide formulation must be applied within a specific distance, you must know the dispersal rate of your equipment for the formulation to be dispersed and the speed that you must travel.

a. Calculating dispersal rate. To calculate the dispersal rate of pesticide dispersal equipment, you must collect and measure the quantity of dry or liquid ounces dispersed by the equipment in 1 minute. This number is then multiplied by the number of minutes in an hour and then divided by the number of ounces contained in a pound or a gallon, depending upon the type of material.

(Dispersal rate formula):

$$X = 0 \times \frac{60}{128/16}$$

Where:

X = dispersal rate
0 = ounces (dry or liquid) in 1 minute
60 = constant (minutes in hour)
128 = constant (ounces in gallon if formulation is liquid) (table 1-1)
16 = constant (ounces in pound if formulation is dry) (table 1-1)

Example: Determine the number of gallons a John Beam Sprayer disperses in an hour when 80 ounces are collected in 1 minute.

$$X = 0 \times \frac{60}{128}$$

$$X = 80 \times \frac{60}{128}$$

$X = 37.5$ gal per hr

NOTE: The previous formula and the formulas that follow can be used with either dry formulations, such as dusts and granules, or liquid formulations simply by substituting pounds with gallons, dry ounces with liquid ounces, or vice versa.

b. Calculating travel speed. To calculate the speed that the pesticide dispersal equipment must travel, you must know the dispersal rate of the equipment, which was done in the previous example, and the quantity of pesticide to be applied per mile. The quantity of pesticides to be applied per mile is identified on pesticide labels.

NOTE: The remaining formulas in this objective will be based on known and unknown information. The known information is provided in each example and the unknown information is what you will be determining.

(Speed per hour formula):

$$\text{Speed} = \frac{\text{dispersal rate per hour}}{\text{quantity per mile}}$$

Example: A pesticide label specifies that this pesticide must be applied as a finished spray the rate of 40 gallons per mile. The equipment that you are going to use has been proven to disperse 35.5 gallons per hour, and now you must determine the speed that you must travel to obtain the proper application rate.

Unknown: Speed per hour
Known: Dispersal rate per hour
Quantity per mile

$$\text{Speed} = \frac{\text{dispersal rate per hour}}{\text{quantity per mile}} \qquad \text{Speed} = \frac{35.5}{40}$$

$$\text{Speed} = 0.88 \text{ miles per hour}$$

Area application formulas. Information pertaining to the dispersal of pesticides over a given area is specified on the pesticide label; however, area application rates are expressed differently from those for linear applications.

To perform area applications of pesticides properly, you must know the formulas for calculating various information that is required, such as the flow rate of the equipment to be used, speed in which the equipment must travel, the amount of area to be treated, the gallons of finished spray required, the gallons of finished spray to be applied per acre, and the spray strength.

The formula for calculating the flow rate of equipment has already been discussed under the subject of linear application, and the formula for calculating the amount of area to be treated was discussed in objective 417. Therefore, discussion within this objective will continue with the formulas for calculating the unknowns such as speed of travel for equipment, the gallons of finished spray required, and the gallons of finished spray to be applied per acre.

a. Calculating quantity of finished product. Determining the gallons or pounds of finished product is required when the pesticide label specifies that the pesticide must be applied at the rate of X gallons per pounds per acre.

(Quantity of finished product formula):

$$\text{Quantity required} = \frac{\text{square feet} \times \text{quantity per acre}}{43{,}560 \text{ (square feet in an acre)}}$$

Example. A pesticide label specifies that the pesticide must be applied at the rate of 120 gallons of finished spray per acre. The area to be treated is 60,480 square feet. How much of the finished product will be required to treat the entire area?

Unknown: Quantity required
Known: Quantity per acre
Square feet in area
Square feet in an acre (table 1-1)

$$\text{Quantity required} = \frac{\text{sq ft} \times \text{gal per acre}}{43{,}560}$$

$$\text{Quantity required} = \frac{60{,}480 \times 120}{43{,}560}$$

$$\text{Quantity required} = 166.61 \text{ gallons of finished product}$$

b. Calculating speed in feet per minute. Once you have determined the quantity of pesticide that is required to treat an area you must then determine the speed that you must travel to disperse the total quantity at the proper rate over the entire area. The following formula is used to determine the speed in feet per minute that you must travel to apply a given quantity of finished product to a given number of square feet.

(Speed in feet per minute formula):

$$\text{Speed} = \frac{43{,}560 \times \text{quantity dispersed per minute}}{\text{Width} \times \text{quantity dispersed per acre}}$$

Example: A pesticide label specifies that a pesticide must be applied at the rate of 100 pounds of finished product per acre. The area that requires treatment is 2.3 acres, and the equipment to be used has been calculated to disperse 4 pounds per minute and has a swath width of 20 feet. How fast must this equipment travel to apply this pesticide over the entire area at the specified rate.

Unknown: Speed in feet per minute
Known: Square feet in acre (table 1-1)
Dispersal rate per minute
Swath width
Quantity per acre

$$\text{Speed in ft per min} = \frac{43{,}560 \times \text{lb dispersed per min}}{\text{swath width} \times \text{lb dispersed per acre}}$$

$$\text{Speed in ft per min} = \frac{43{,}560 \times 4}{20 \times 100}$$

$$\text{Speed in ft per min} = 87.12 \text{ (or 0.99 mph)}$$

NOTE: To convert the speed in feet per minute to speed in miles per hour, simply divide the speed in feet per minute by 88 because this is the number of feet of travel at 1 mph.

c. Calculating quantity per hour. There will be times when it will be necessary for you to determine the quantity of finished product that is required to be applied over a designated area. As an example of this, you may be required to furnish this type of information for it to be included in the Base Environmental Impact Statement.

(Quantity rate per acre formula):

$$\text{Quantity rate per acre} = \frac{43{,}560 \times \text{qnty dispersed per min}}{\text{swath width} \times \text{speed in ft per min}}$$

Example: You have just completed a pest management operation that involved the treatment of 12 acres for the control of bagworms using a suspension formulation that was prepared and applied in accordance with the rates specified on the pesticide label. The pesticide was applied with a nonportable mist-dust blower which has a dispersal rate of 3 gallons per minute and a swath width of 40 feet. The speed of travel was 3 mph or 264 feet per minute. The finished product was applied at the rate of how many gallons per acre?

Unknown: Quantity rate per acre
Known: Square feet in an acre (table 1-1)
Dispersal rate per minute
Swath width
Speed in feet per minute

$$\text{Quantity rate per acre} = \frac{43{,}560 \times \text{gal dispersed per min}}{\text{swath width} \times \text{speed in ft per min}}$$

$$\text{Quantity rate per acre} = \frac{43{,}560 \times 4}{40 \times 264}$$

$$\text{Quantity rate per acre} = 12.375 \text{ or } 12.38 \text{ gallons per acre}$$

Exercises (419):

Solve each of the calculation problems (to the nearest hundredths) provided below.

1. How many pounds of dust can be dispersed from a nonportable mist-dust blower in 1 hour if 93 ounces are dispersed in 1 minute?

2. The pesticide label specifies this pesticide to be applied as a finished spray at the rate of 7 gallons per mile. The equipment that will be used will disperse 35 gallons per hour. At what speed should this equipment travel to obtain the proper application rate?

3. You are to treat an area 3 miles long by 10 feet wide for ticks. The label of the pesticide that is to be used specifies it should be applied at a rate of 75 gallons of finished spray per acre. How much of the finished product is needed to treat the entire area?

4. You are to apply insecticide dust to 3.8 acres using a Buffalo Turbine which disperses 8 pounds per minute with an effective swath width of 50 feet. The insecticide you are to use is to be applied at a rate of 75 pounds per acre. At what speed (in mph) must your equipment travel to apply this product at the specified rate?

5. It is necessary to treat 25 acres for the control of sod webworms using a granular formulation prepared and applied in accordance with specified pesticide label rates. This will be applied with a turbine mist-dust blower which has a dispersal rate of 4 pounds per minute and a swath width of 50 feet. The speed of your equipment will be 5 mph. How many pounds per acre will be applied?

420. Solve given formulation calculations problems.

Formulation Calculations. Dusts are usually purchased ready to use, but may be diluted for special purposes with one of the inert carriers. Technical grade pesticides and their solvents do not usually have the same specific gravity or weight per gallon. They cannot, therefore, be mixed according to volume, but must be prepared on a weight-to-weight basis. They may then be further diluted by volume with sufficient accuracy, as the specific gravity of the ingredients has been compensated for in the preparation of the concentrate. Chlordane, for example, weighs twice as much as kerosene. A solution containing 2 gallons of technical chlordane and 98 gallons of kerosene would contain 4 percent of chlordane by weight, not 2 percent. A chlordane 20 percent concentrate, however, contains 20 percent chlordane by weight. Therefore, it may be diluted by volume in the proportion of 1:9 to produce a 2 percent finished spray. Figure 1-3, Proportional Ratio, illustrates the principles for selecting the correct formula to use in diluting pesticidal concentrates.

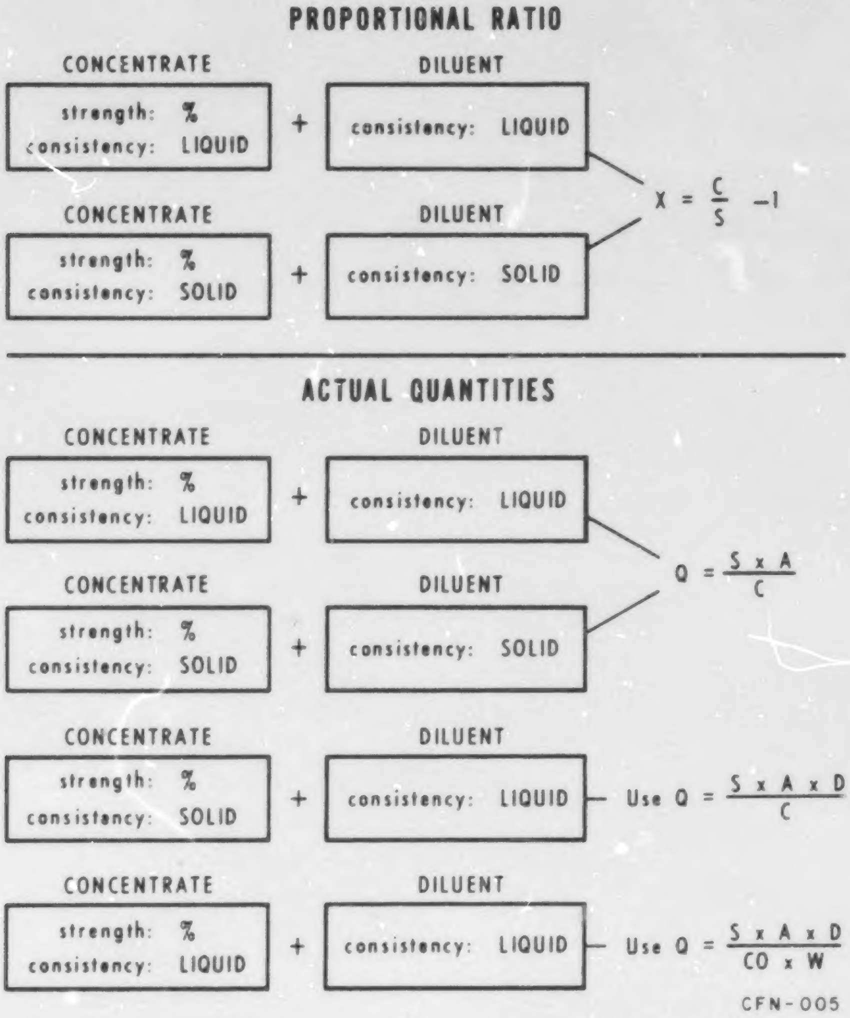
PROPORTIONAL RATIO
CONCENTRATE
DILUENT
strength: %
consistency: LIQUID
+
consistency: LIQUID
X = C/S −1
CONCENTRATE
DILUENT
strength: %
consistency: SOLID
+
consistency: SOLID
ACTUAL QUANTITIES
CONCENTRATE
DILUENT
strength: %
consistency: LIQUID
+
consistency: LIQUID
Q = S x A / C
CONCENTRATE
DILUENT
strength: %
consistency: SOLID
+
consistency: SOLID
CONCENTRATE
DILUENT
strength: %
consistency: SOLID
+
consistency: LIQUID
Use Q = S x A x D / C
CONCENTRATE
DILUENT
strength: %
consistency: LIQUID
+
consistency: LIQUID
Use Q = S x A x D / CO x W
CFN-005

Figure 1-3. Proportional ratio.

Proportional formula. This is a simple dilution formula for diluting a liquid with a liquid, or a solid with a solid. This formula is a *ration*, such as 1:19, and does not give the amount of concentrate required to prepare a certain quantity such as 5 gallons of 50 percent malathion emulsifiable concentrate (see examples 1 and 2 below).

Proportional Formula (Ratio for diluting liquid with liquid, or dust with dust):

$$X = \frac{C}{S} - 1$$

Where:

X = number of parts of diluent to add to 1 part of concentrate
C = concentrate, percent of active ingredient
S = strength of percent of active ingredient in finished spray or dust.

Example 1. Prepare 100 gallons of 2.5 percent malathion emulsion from 50 percent malathion emulsifiable concentrate and water.

$$X = \frac{C}{S} - 1$$

$$X = \frac{50\%}{2.5\%} - 1$$

$$X = \frac{20}{1} - 1$$ or 19 parts of diluent, *or* (1:19 dilution ration)

With a total of 20 (10 + 1) parts, each part equals $\frac{100 \text{ gallons}}{20 \text{ parts}}$ or 5 gallons of 50 percent malathion emulsifiable concentrate. Add 5 gallons of 50 percent malathion emulsifiable concentrate to 95 gallons of water to make 100 gallons of 2.5 percent malathion emulsion.

Since many small pesticidal applications involve 1 gallon quantities, and it is difficult to measure parts of a gallon accurately, it is wise to remember that one gallon contains 128 ounces and to work with the ounce dilution ration.

Example 2. Prepare 1 gallon (128 ounces) of 2.5 percent malathion from 50 percent malathion emulsifiable concentrate and water for use in a hand sprayer.

$$X = \frac{C}{X} - 1$$

$$X = \frac{50\%}{2.5\%} - 1$$

$$X = \frac{20}{1} - 1 \quad \text{or 19 parts of diluent, or (1:19 dilution ratio)}$$

With a total of 20 (19 + 1) parts, each part equals $\frac{128\text{ oz}}{20\text{ parts}}$ or 6.4 ounces.

Add 6.4 ounces of 50 percent malathion emulsifiable concentrate to the hand sprayer and fill to the 1 gallon fill mark on the tank. Use a plastic or metal measuring cup for accurate measurement.

SAC formula. This formula is used when it is desired to produce a certain quantity of pesticide using materials of the same form, such as liquid with liquid, or solid with solid (see examples 3,4, and 5 below).

SAC formula (for preparing certain quantity):

$$Q = \frac{S \times A}{C}$$

Where:

Q = quantity of concentrate required in mixture (pounds, gallons, ounces).
S = strength or percent of active ingredient in the finished dust or spray
A = amount of finished spray or dust to be prepared (pounds, gallons, or ounces)
C = concentrate, percent of active ingredient

Example 3. Prepare 100 pounds of 10 percent malathion dust using 75 percent malathion dust and talc:

$$Q = \frac{S \times A}{C}$$

$$Q = \frac{10\% \times 100\text{ lb}}{75\%} = \frac{1000}{75} = 13.33\text{ lb}$$

Add 13.3 pounds of 75 percent malathion dust to 86.7 of talc to make 100 pounds of 10 percent dust.

Example 4. Prepare 100 gallons of 0.5 percent diazinon emulsion using 20 percent diazinon emulsifiable concentrate and water.

$$Q = \frac{S \times A}{C}$$

$$Q = \frac{0.5\% \times 100\text{ gal}}{20\%} = 2.5\text{ gal}$$

Add 2.5 gallons of 20 percent diazinon emulsifiable concentrate to 97.5 gallons of water to make 100 gallons of 0.5 percent diazinon emulsion.

Example 5. Prepare 1 gallon (128 ounces) of 0.5 percent diazinon emulsion from 20 percent emulsifiable concentrate and water.

$$Q = \frac{S \times A}{C}$$

$$Q = \frac{0.5\% \times 128\text{ oz.}}{20\%} = \frac{64\text{ oz}}{20} = 3.2\text{ oz}$$

Place 3.2 fluid ounces of 20 percent diazinon emulsifiable concentrate in the sprayer and add enough water to make 1 gallon.

SAD SAC formula. This formula is used when it is desired to produce a certain quantity of insecticide from ingredients whose form is different, such as mixing a solid wettable powder with water to produce a suspension (see examples 6,7, and 8 below.)

SAD SAC formula (weight to volume formula):

The following formula may be used to prepare a solution of suspension on a w/v (weight to volume) basis using either the technical grade insecticide or a concentrate.

$$Q = \frac{S \times A \times D}{C}$$

Where:

Q = pounds of concentrate to use
S = strength of percentage of active ingredients in the finished spray
A = amount in gallons of finished spray
D = density: weight of 1 gallon of diluent (water is 8.34 lb/gal)
C = concentrate: Percentage of active ingredient

Example 6. Prepare 100 gallons of 1.25 percent malathion suspension from 75 percent wettable powder and water.

$$Q = \frac{S \times A \times D}{c}$$

$$Q = \frac{1.25\% \times 100\text{ gal} \times 8.34\text{ lbs/gal}}{75\%}$$

$$Q = \frac{1{,}042{,}50}{75}$$

Q = 13.9 lbs of 75 percent water dispersible powder.

Fill the mixing tank with most of the 100 gallons of water. Add the 13.9 lbs of 75 percent water-dispersible powder and mix. Fill to the 100-gallon level.

Example 7. Prepare 1 gallon of 2.5 percent malathion suspension from 75 percent water-wettable powder and water.

$$Q = \frac{S \times A \times D}{C}$$

$$Q = \frac{2.5\% \times 1 \text{ gal} \times 8.34 \text{ lb/gal}}{75\%}$$

$$Q = \frac{20.85}{75}$$

Q = 0.28 lb (4.5 oz) of 75% water dispersible powder.

Add 4.5 oz. of 75 percent wettable malathion powder to the hand sprayer. Add water slowly with constant mixing to the gallon mark.

Example 8. Prepare 7.5 liters (7500 ml or about 2 gallons) of 5 percent suspension from 75 percent malathion wettable powder.

$$A = \frac{S \times A \times D}{C}$$

$$Q = \frac{5\% \times 7500 \text{ ml} \times 1 \text{ gm/cc}}{75\%}$$

Q = 500 gm of 75 percent water wettable powder

Place 500 grams of 75 percent wettable malathion powder in the 2-gallon sprayer. Add a small amount of water and stir to make a slurry. With constant stirring, add water slowly to the 7500 ml mark.

This formula may be used to prepare solutions and suspensions on an accurate basis. After the amount of material to be used has been computed and weighed, place it in a container and make a permanent mark to be used when solutions or suspensions are being prepared by field personnel. They will then be able to mix chemicals by volume without using scales to make measurements each time a tankful is to be mixed.

SAD COW formula. This formula is used when the liquid concentrate is prepared on the basis of pounds of pesticide per gallon of formulation (see example 9 below).

The following formula may be used to dilute liquid concentrates prepared on the basis of pounds of pesticide per gallon.

$$Q = \frac{S \times A \times D}{CO \times W}$$

Where:

Q = quantity of concentrate required in gallons
S = strength of percentage of active ingredients in the finished spray
A = amount of spray to be prepared in gallons
D = density: weight of gallon of diluent, ususally water (8.34 lbs)
CO = concentrate: 100 percent
W = weight of the pesticide concentrate in pounds per gallon

Many pesticides are now sold with the label indicating pounds of pesticide per gallon rather than percentage of toxic materials; examples are chlordane—8 pounds per gallon, or 4 pounds per gallon. In this case, the weight-to-weight formula is modified so that the factor CO is considered as 100 percent, and a factor W-pounds of pesticide per gallon is added.

Example 9. Prepare 100 gallons of 0.5 percent chlordane emulsion from an emulsifiable concentrate containing 4 pounds per gallon.

$$Q = \frac{S \times A \times D}{CO \times W}$$

$$Q = \frac{0.5\% \times 100 \text{ gal} \times 8.34 \text{ lb/gal}}{100\% \times 4 \text{ lb/gal}}$$

Q = 1.04 gallons of chlordane concentrate

Add 1 gallon of 4 pounds/gallons chlordane concentrate to sufficient water to make 100 gallons of finished spray.

Exercises (420):

Solve each of the following formulation calculation problems to the nearest hundredths.

1. Prepare 200 gallons of 1 percent spray using a 20-percent emulsifiable concentrate. How much emulsifiable concentrate is required?

2. Prepare 100 gallons of .5 percent suspension using 25 percnet wettable powder insecticide. How many pounds of 25 percent wettable powder are required?

3. Prepare 50 gallons of 1 percent emulsion using an emulsifiable concentrate containing 1.5 pounds active ingredient per gallon. How much concentrate is required?

4. Prepare 100 pounds of .025 percent warfarin using a .5 percent concentrate. What is the dilution ratio?

5. Prepare 5 pounds of 2 percent dusting powder using 25 percent wettable powder and talc. How much concentrate is required in ounces?

6. Prepare 2 gallons of 1 percent suspension using a 10-percent wettable powder. How many pounds of concentrate is required?

421. Solve given herbicidal calculation problems.

Unique Calculations for Herbicides. This objective has been included to discuss calculations that are primarily restricted to the formulation and application of herbicides. In most cases, the calculaiton formulas *given previously will apply to herbicides;* however, some herbicide labels give formulation and application instructions that are not common with other pesticide labels. The following formulas should assist you in formulating and applying herbicides when the herbicide label contains information that may be uncommon to you at this point.

Calculating acre-feet of water. Calculating the acre feet contained in a body of water may be required when a pesticide must be applied per acre-foot of water. Although the use of the following formula is not common for insecticides, it is frequently used for herbicidal applications to aquatic vegetation.

(Acre-feet of water formula):

$$\text{Acre-feet of water} = \text{surface acres} \times \text{average depth of water in feet}$$

Example: Determine the acre-feet of water contained in a body of water that has an overall surface area of 2 acres and an average depth of 3 feet:

$$\text{Acre-feet of water} = \text{surface acres} \times \text{average depth of water}$$
$$\text{Acre-feet of water} = 2 \times 3$$
$$\text{Acre-feet of water} = 6$$

Calculating product rates of liquid formulations. Calculating product rates may be required when using herbicides and is almost entirely unique for herbicidal applications. The following formula is used to determine the product rate when AFM 91–, *Herbicide Manual For Noncropland Weeds,* specifies that it is to be applied at a standard rate per acre using X number of pounds of active ingredient (AI) or acid equivalant (AE) per acre.

(Product rate formula for liquid formulations):

$$\text{Product rate per acre} = \frac{\text{standard rate per acre}}{\text{lb of AI per gal}}$$

$$\text{Product rate per acre} = \frac{10}{4}$$

$$\text{Product rate per acre} = 2.5 \text{ gallons}$$

Calculating product rates of dry formulations. Calculating product rates of dry materials is required when the herbicide label specifies that the herbicide contains a certain percent of active ingredient and it must be applied at the standard rate identified by AFM 91–19.

(Product rate formula for dry formulations):

$$\text{Product rate per acre} = \frac{100}{\%\ \text{AI}} \times \text{Standard rate per acre}$$

Example: A herbicide label specifies that the herbicide is 80 percent active ingredient and AFM 91– specifies that the herbicide used for this operation must be applied at the standard rate of 10 pounds per acre. What is the product rate of the herbicide applied?

$$\text{Product rate per acre} = \frac{100}{\%\ \text{AI}} \times \text{standard rate per acre}$$

$$\text{Product rate per acre} = \frac{100}{80} \times 10$$

$$\text{Product rate per acre} = 12.5 \text{ pounds}$$

Calculating total product to be applied to a body of water. When herbicides are to be applied to control aquatic vegetation it is often necessary to calculate the quantity of herbicide to be applied in ppm (parts per million). The following formula is used to determine the quantity of total product required when the rate of application is given in parts per million.

(Quantity of total product for ppm application formula):

Total product = parts per million × acre-feet of water × 2.7

NOTE: The 2.7 is constant because 1 acre-foot of water weighs 2,722,500 pounds; therefore, one part per million equals 2.7 pounds of chemical to be added to each acre-foot of water.

Example. A herbicide is to be applied to 6 acre-feet of water at the rate of 2 ppm. How much of the total product will be required to treat this body of water?

$$\text{Total product} = \text{ppm} \times \text{acre-ft of water} \times 2.7$$
$$\text{Total product} = 2 \times 6 \times 2.7$$
$$\text{Total product} = 32.4 \text{ pounds}$$

NOTE: Once you have determined the quantity in pounds of total product that will be required to treat the area, you will need to convert the pounds of total product into pounds of active ingredient. This is done by using either the product rate formula for liquid formulations or the product rate formula for dry formulations which were provided at the beginning of this objective.

Exercises (421):

Solve each of the following herbicidal calculation problems (to the nearest hundredths).

1. The product rate to be applied when a herbicide must be applied at a standard rate of 5 pounds of active ingredient per acre that contains 2 pounds of active ingredient per gallon would be?

2. How much total product of a herbicide is required to treat a lake at the rate of 2 ppm that has a surface area of 12 acres and has an average depth of 5 feet?

3. The product rate to be applied when a herbicide is to be applied at the standard rate of 5 pounds per acre using a 75 percent active ingredient product would be?

422. Identify pesticide particle size with the type of application.

Pesticide Application and Particle Size. The effectiveness of a pesticide is greatly influenced by the size of the droplets or particles into which it is broken when applied. For example, in residual applications, a spray is desirable in order to wet the surface and leave a long-lasting deposit; whereas in space spraying, to kill mosquitoes and flies on the wing, a mist or fog should be used so that the pesticide will remain suspended in the air for a time to kill the insects exposed to the droplets. Pesticides may be applied either as liquid or as dusts.

Liquid sprays. Liquid sprays range from rain-like drops delivered by orchard sprayers to mists and fogs produced by mist, fog, or aerosol generators. It is impossible to break up a liquid into entirely uniform droplets, although the range of droplet size may be considerably restricted. There are always some fine droplets among the others, even when the spray is rather coarse. The usual practice is to refer to the *mass median diameter* (MMD) of the spray, which is the droplet diameter that divides the volume or mass of the spray into two equal portions, respectively, more finely and more coarsely atomized. The unit of measurement is the micron, 1/1000 of a millimeter or about 1/25,000 of an inch. The average diameter of a human hair is about 100 microns.

Coarse sprays contain droplets 400 microns or more in diameter, which are produced with coarse disc nozzles or solid-stream gun nozzles.

Fine sprays have droplets ranging from 100 to 400 microns, produced with high pressure through hollow-cone and fan-spray nozzles.

Mists range in droplet size from 50 to 100 microns in diameter. They are produced by high-pressure pumps, high-speed mechanical rotors, and atomizers.

Aerosols, smokes, and fogs. Aerosols, smokes, and fogs may be defined as assemblages of solid particles or liquid droplets suspended in air and ranging in size for 0.1 to 50 microns. Pesticidal aerosols and fogs may be produced by spraying insecticides into a blast of hot air as with the thermal aerosol generator, or by mixing them with a liquefied gas which is then released through small orifices, as with the household "bug bomb." They can also be produced by atomization from very fine nozzles, or by being thrown off the rim of high-speed rotors.

Fumigants. This includes fumes, vapors, and gases and consists of particles in the range of 0.001 to 0.1 microns in diameter. These are common in the output of thermal fog generators, vapor producing equipment, and the release of fumigant compounds within the atmosphere.

Dusts and granules. Pesticidal dusts occur in three sizes:

Coarse dusts have a particle size about 175 microns or larger, which include granules.

Medium dusts range from 45 to 175 microns.

Fine dusts have a particle size of 44 microns or less.

Fine dust particles will pass through a 325-mesh screen, i.e., one with 325 wires to the inch. A coarse dust is used where excessive drift must be avoided, as in airplane application.

During the past few years, increasing concern has been expressed about the effects of pesticides on nontarget organisms, particularly from the buildup of pesticides in the environment following repeated applications. Therefore, there has been great interest in recent research indicating that very effective control of insects could be obtained by dispensing very small amounts of pesticide (such as 0.5 ounce of naled or 3 ounces of malathion per acre) in the form of millions of tiny droplets evenly dispersed over large areas.

Today it is assumed that the effectiveness of a pesticide increases with an increase of its exposed surface. For droplets of different diameters, the volumes are to each other as the cubes of the diameters, while the surfaces are to each other as the squares of the diameters. Thus, for equal volumes of one aerosol dispersed as droplets of 50 microns in diameter and another as droplets of 5 microns in diameter, there would be 10 × 10 × 10, or 1000 times, as many of the smaller droplets, while the surface area of the smaller droplets would be 10 × 10, or 100 times, as great as the total surface area of the larger droplets.

Exercises (422):

1. Match pesticide particle size ranges with the type of application by placing the alpha letter of the particle size range in the blank beside the appropriate application.

Pesticide Application	*Particle Size Range in Microns*
____ 1. Aerosols and fogs.	a. 0.001 - 0.1
____ 2. Fine sprays.	b. 0.1 - 50.
____ 3. Fumigants.	c. 50 - 100.
____ 4. Medium dusts.	d. 45 - 75.
____ 5. Mists.	e. 100 - 400.

Complete the following statements:

2. The average diameter of a human hair is about __________ microns.

3. The effectiveness of a pesticide is greatly influenced by the __________ of the particles when applied.

4. If you were applying pesticide particles that range in size from 0.1 to 50 microns as opposed to particles that range in size from 50 to 100 microns, the effectiveness of the pesticide would __________ (increase/decrease).

1-3. Effects of pesticides on the Environment

The environment is our surroundings and its many forms of life. Every plant or animal is affected by other plants and animals in the environment. Factors like rain, temperature, and wind are part of the environment, and these factors can affect pesticides, which in turn affect the environment. Although rain, temperature, and wind cannot be controlled, the use of pesticides can.

In order to understand the effects of pesticides on the environment, ecology must be discussed to identify the important environmental elements and their relationship to each other. In addition to this, you must also be able to distinguish and understand the difference between pesticide toxicity and pesticide hazard. Once you understand the relationship of the environmental elements and the toxicity and hazards of pesticides, you can then realize the beneficial and detrimental aspects of pesticides.

423. Define ecology and assess the importance and role of identified environmental elements:

Ecology. Ecology is defined as the study of the relationship of living things, the environment they live in, and their relation to other living things. Literal translation of the word ecology is "household or place to live"; therefore, a pond could be the household for a fish. The water, oxygen, and other aquatic life would be the environment of the fish.

As a pest manager, you must understand the importance of each element within the environment because you are in a position to increase or decrease environmental hazards. You have a responsibility of managing pests effectively and economically in a method that will not adversely affect the environment.

This objective is designed to enable you, as a pest manager, to recognize the interdependence of all elements within the biosphere and to select pest control methods that will reduce hazards to the environment.

Life within the environment is a very thin layer of the atmosphere. This thin layer of life is scientifically referred to as the *biosphere*. The biosphere consists of *biotic* (living) elements and *abiotic* (nonliving) elements. Interaction and continuous recycling of these two elements constitute an *ecosystem*.

Abiotic elements. Nonliving elements within an ecosystem play an important role in the interdependency within the biosphere because they are required for the growth and development of the living elements. Nonliving elements within the biosphere consist of several cycles and are referred to as the natural cycles. Carbon, nitrogen, oxygen, hydrogen phosphorous, and iron are only a few of the natural cycles. Although there are many natural cycles, you will only study the three that are considered to be most basic.

The carbon cycle is the basic element within the ecosystem. Most carbon in living organisms is carbon dioxide (CO2). First, we see carbon dioxide being used by photosynthetic plants (plants essential in producing ~~light~~ sugar). These plants require carbon dioxide along with other elements to manufacture food for the plants. These plants then store the food in tissues then are eaten by herbivores. Herbivores synthesize (transform) the carbon compound into other compound forms. In turn, the herbivores are consumed by the carnivores that redigest and synthesize the carbon once again into other compounds. Some of the carbon is released back into the atmosphere as CO2, while the remaining carbon is disposed of as a excretory waste. Bacteria and fungi feed on this organic matter and reduce it into simple elements again. At this stage, most of the organic carbon is released in the atmosphere as carbon dioxide, and the remaining portions are drawn into the earth's surface and eventually transformed into coal.

The nitrogen cycle is also important; because it too, aids plant growth. Plants obtain nitrogen directly from the soil with the assistance of bacteria living in the plant roots. From this point, the cycle continues on and on, just as the carbon cycle.

Another important natural cycle is the relatively simple oxygen cycle. As you know, oxygen is a by-product of photosynthesis. Oxygen can be found in air and water and is vital in the respiration process of green plants and consumers of green plants. The consumers of green plants take in oxygen from the atmosphere and they transpose oxygen into carbon dioxide, which is expelled and taken in by the green plants. The green plants then transpose carbon dioxide into oxygen; so this process continues its cycle.

As stated earlier, there are many more equally important natural cycles that could be discussed, but the need to divert the discussion to the biotic elements is in order at this time.

Biotic elements. Green plants and *consumers of green plants* are the two prime living elements in each ecosystem. Green plants are considered to be the primary biotic element because they manufacture food from energy of the sun and inorganic matter. Green plants provide an integral link in the natural food chain by storing the sun's energy and passing it through the ecosystem in a series of steps of eating and being eaten. Green plants are also very important in the respiration process, as previously explained in the paragraph concerning the oxygen cycle.

Just like green plants, the consumers of green plants are also vital in the respiration process. Their relation in the respiration process and the dependency of each element is also explained in the oxygen cycle. Consumers of green plants include (but are not limited to) animals, insects, bacteria, and fungi; and they too, provide another important link within the food chain.

Up to this point, you have studied the importance of abiotic and biotic elements within the ecosystem and have realized their relationship in the respiration process, but more discussion should be devoted to their relationship and dependency within the food chain. This relationship and dependency of the abiotic and biotic elements within the food chain can be better understood by using the following example.

The abiotic elements are required to provide food for the green plants which are considered to be the basic food element within thee ecosystem. Green plants then provide food for the herbivores (plant eaters, such as rabbits) and omnivores (plant and meat eaters, such as man). Rabbits are then eaten by the carnivores (meat eaters, such as coyotes) and again the omnivores. Other carnivores such as bears, hawks, and vultures kill and eat the coyotes and each other. Then comes man, who kills various carnivores for food and sport, and in turn, man dies. With the death of plants, herbivores, carnivores, and omnivores comes the food source for the decomposers (bacteria, fungi, and protozoa). As the decomposers feed, they return essential organic matter to the soil to support plant growth; thus, completing the food chain.

Discussion about phytoplanktons has been reserved for last because they consist of both green plant and consumers of green plant matter. Phytolanktons are very minute organisms that float about in various bodies of water and are the principal producers of photosynthesis. It is estimated that they produce 70 percent of the earth's photosynthesis which is required for oxygen renewal in the atmosphere.

Based upon this information, it is understandable that each cycle and element is dependent upon each other, and the interaction between them is required to support each ecosystem. The biosphere is constantly undergoing changes and each change affects an ecosystem; thus, it is your responsibility to insure that you do not present hazards that could immensely affect the environment.

Exercises (423):

1. Define ecology.

2. What is the biosphere?

3. The basic element within the ecosystem is the ______________ cycle.

4. Describe the interdependence of green plants and animals in the respiration process.

5. Describe the role played by the abiotic elements within the biosphere.

6. What are the two prime living elements contained in each ecosystem?

7. What is considered to be the primary biotic element?

8. State the importance of animals to green plants within the food chain.

9. Describe phytoplanktons.

10. State the role of importance played by bacteria, fungi, and protozoa within the food chain.

424. Identify the beneficial and detrimental aspects of pesticides.

Impact of Pesticides in the Environment. In order to discuss and understand the full impact pesticides have in the environment, you must look at the beneficial and detrimental aspects.

Pesticides may be beneficial or detrimental, and at times, simultaneously, depending upon their use. This comment can be better understood as the discussion progresses.

Beneficial aspects of pesticides. Pesticides are required to manage pests of medical and economical importance. Without the aid of pesticides, farmers could not produce enough yield from the crops to support the increased population because these crops would be severely damaged by the spread of undesirable plants and plant eating insects. Structures could be rendered unsafe and totally destroyed by many fungi and insects if the structures are not treated with pesticides. Pesticides have contributed immensely in the decline of many diseases that were dreadfully feared a few years ago because of the number of cases causing death. Today, many of these diseases are almost nonexistent and rarely spoken of in the United States due to using pesticides.

There are many vertebrate animals, insects, arachnids, and others that are responsible for transmitting diseases and are venomous; in addition, many are simply a nuisance, causing humans to lose sleep and not be able to enjoy outdoor activities. From this information, you can understand that pesticides are required to maintain a healthy and prosperous Nation, and they do have a beneficial role in our environment.

Detrimental aspects of pesticides. Pesticides present many hazards to the environment because they can affect many biotic elements. Generally, these effects are very minor and temporary; however, if pesticides were continually used without proper knowledge of their hazards and without concern, the effects could become severe and permanent.

In order to fully understand the importance of this section, the possible long-range effects of continuous misuse of pesticides must be considered and remembered throughout.

The major problem with pesticides is the effect they may have on nontarget organisms (organisms that are not intended to be affected). Regardless of how carefully pesticides are applied, there is always a possibility of destroying nontarget organisms. This can occur either directly or indirectly.

Direct destruction of nontarget organisms is usually the result of applying pesticides to kill target organisms when nontarget organisms are in the same area; therefore, both organisms would be killed. This is a perfect example of a pesticide being beneficial and detrimental at the same time.

Indirect destruction of nontarget organisms is generally caused by pesticides moving off target through natural environmental conditions such as the air, soil, and water.

When pesticides are being applied outdoors, pesticide particles (liquids or dusts) are carried off target by wind currents. These particles may remain in the wind currents for a long period of time and transferred to an area several miles away. During the drift, some particles are caught on trees, others eventually settle to the ground, and the remaining few may be suspended in the atmosphere. Aerial application of pesticides presents the greatest problem of pesticide drift, followed by the fogging of outdoor areas for mosquito control and the application of residual pesticides to trees and shrubs.

Soils are contaminated with pesticides in many ways other than drifting pesticide particles settling to the ground. The suspended pesticide particles in the atmosphere may be released to the ground as rains cleanse the atmosphere of many other suspended particles. Rain will also wash pesticide particles from buildings, trees, shrubs, and grasses; thus the particles accidentally contaminate the soils. Once pesticide particles are in the soil, they may move throughout the soil by leaching.

Almost all pesticide particles eventually end up in water regardless of how carefully they are applied. As pesticide particles drift through the air, they fall to the earth's surface and settle on trees, shrubs, grasses, soils, streams, rivers, ponds, lakes, and oceans. Rains increase the amount of pesticide particles in water by removing particles from the air and transferring them from the trees, shrubs, grasses, and soils through runoff and leaching. When this occurs, the pesticide particles are carried to ponds and streams. These particles collect and increase as they are transferred to rivers, lakes, and oceans that may be a great distance from the original target.

Persistent pesticides probably contribute more environmental hazards than any other product, because they do not break down very easily or quickly. These pesticides may remain stable for weeks months, or even years in the air, soil, water; furthermore, some amy actually transform into a more toxic compound than the original compound after several years. The prime concern over the use of persistent pesticides is the effect they may have on the food chain. The food chain can be severely jeopardized by these persistent compounds. For instance, an area is treated with a persistent compound to manage grubs that are destroying turf. The grubs come in contact with the compound and are killed. Along come the moles that feed on the grubs. Some may die, others may live, but now they have the comound stored in their bodies. The toxicity level may increase within their bodies, and when they are eaten by other animals, the toxicity level may be so high that the predator will be killed. This process can continue throughout the food chain and eventually affect humans. These effects may be nervous disorders, cancer, birth defects, or death from high toxicity levels. Traces of many persistent pesticides can be found in almost any product from eggs to breast milk, and the sad part about the whole process is that these persistent pesticides can be stored and transferred through a continuous cycle.

As yet, pesticides have not completely destroyed any particular element within the environment; however, they have disrupted certain elements and have caused a lot of concern from time to time.

Keeping in mind the statement made previously about the possible long-range effects, it is conceivable that pesticides could destroy certain elements in the future, if used improperly. Protecting the environmental elements from pesticides is your responsibility and is the subject of discussion in the next objective.

Exercises (424):

1. List the beneficial aspects of pesticides from the economical standpoint.

2. List the beneficial aspects of pesticides from the medical standpoint.

3. When could the detrimental effects of pesticides become severe and permanent?

4. What is the major problem with pesticides?

5. List the methods by which pesticides may contaminate soils?

6. Describe the methods in which rain can contaminate soils with pesticides.

7. Describe a persistent pesticide.

8. Describe the hazards that can be presented by pesticides within the food chain.

9. A characteristic of some persistent pesticides is their ability to transform into a more __________ compound than the __________ compound after several years.

425. Specify methods for reducing pesticide hazards in the environment.

Methods of Reducing Pesticide Hazards in the Environment. Environmental damage by pesticides can be virtually eliminated by simply adhering to some fundamental pest management principles. Foremost of these principles is the accurate assessment of the pest problem to determine if a pest management operation is really necessary. Then, if a valid pest management requirement actually exists, select and execute measures that will provide maximum pest management results while causing minimal environmental damage (using pesticides as a last resort).

Determine the requirements for pest management programs. Pest management requirements can be accurately determined only after surveying the area concerned to confirm the existence of pest populations and to identify environmental conditions conducive to the existence and propagation of these pest populations. An ongoing pest surveillance program is very effective not only in detecting existing problems, but is also an invaluable tood in indentifying potential pest problems so that timely preventive measures can preclude the need for drastic eradication measures in the future. As a general rule, environmental sanitation techniques, such as elimination of harborage and breeding areas, will prevent buildups of pest populations without causing significant damage to populations of desirable species. Occasionally, the use of biological methods, such as the introduction of predacious minnows to impounded water to feed on mosquito larvae, will provide very satisfactory control of certain mosquito populations. In other instances, mechanical devices or structural modifications to buildings may provide satisfactory results. In any case, pesticides should be used only when there is a substantial need to immediately reduce a pest population and no other feasible technique will do the job.

The following hypothetical situation is an example of problems requiring a certain amount of value judgment as well as expertise in maintaining a high degree of target specificity in applying pesticides. The problem involves a close association between wasps and honeybees in a housing area. The wasps have established several large nests under the eaves of a number of houses in the housing area. This is a matter on considerable consternation among the housing occupants since the wasps, if disturbed, will readily attack and sting human beings. It is a well-established fact that wasp stings are painful in all cases, and in the case of hypersensitive people, will usually cause dangerous (sometimes fatal) allergic reactions.

In selecting a means of eradicating the wasps, the pest management operator finds that he must consider the fate of a large number of honeybees that he has observed working in the flower beds around the houses. Honeybees produce food (honey) and are extremely important crop pollinators (some crops can reasonably be expected to fail in the absence of honeybees); hence, are considered to be highly beneficial insects. Also, honeybees, when away from the hive, are not prone to attack and sting people. The matter of whether or not to apply pesticides for control of the wasps at the risk of killing a number of honeybees requires a value judgment on the part of the pest management operator. In this instance, the human health factor outweighs the beneficial factor associated with the honeybees, and the operator will be justified in using pesticides to kill wasps. However, if the operator is a skilled professional and is reasonably concerned with the preservation of beneficial life forms, he will minimize the damage to the honeybees by selecting a nonpersistent insecticide and apply it with equipment that can direct the chemical directly at the wasp nests. This will confine most of the pesticide to the target area. Any pesticide that drifts to the flowers will quickly degrade and pose little or not threat to the honeybees. To further reduce the risk to the honeybees (and to himself), he will choose to apply the pesticide at night when both the honeybees and the wasps are inactive. Night time applications of pesticides to wasp nests are especially desirable because all the wasps are on the nests at night and the entire colony can be killed with one pesticide application. Also, since wasps are not active at night, this technique will virtually eliminate the possibility of the operator receivng stings from enraged wasps.

As discussed in Volume 2, there are two fundamental types of pest control, natural and applied. Two examples of natural controls are unfavorable weather conditions and predation. Natural controls occur without help of mankind.

Applied controls are those in which human effort is directed toward the control of pests. In the foregoing problem, natural controls could not be relied upon since wasps are not affected by predation and since unfavorable weather conditions do not normally occur until the arrival of winter. In a situation like this, it is necessary to resort to applied controls such as the use of a pesticide to kill the adult wasps and mechanical destruction of the nests to prevent the hatching of a new population of wasps.

Implement preventive and corrective nonchemical controls when possible. When pest management programs are implemented they become applied controls. They should only be implemented if nature cannot manage the pests adequately and quickly enough for the situation. If applied controls are required, preventive or corrective nonchemical controls should be implemented whenever and wherever possible.

Preventive measures are normally preferred because they are designed to forestall the buildup of pest populations. Also, they are almost always more effective and more economical in the long run. Preventive controls consist of good sanitation, construction design and maintenance to exclude pests, and drainage or management of impounded water. Legal controls, such as quarantine measures, are effective in preventing the introduction of alien pests into an uninfested area. Occasionally, preventive controls may also serve as corrective measures.

The routine programming of corrective controls is the least desirable technique because the control measures are intended to cope with pest populations after they have grown to intolerable levels. Such controls do not provide for elimination of pest problems. They simply reduce the problem, temporarily, to tolerable levels. Since these measures seldom produce permanent results, they must be repeated frequently and, as a consequence, are very expensive in the long run. Also, since corrective measures usually require frequent repeated applications of pesticides, they pose a significantly greater threat to the environment. As a rule, corrective controls, particularly the use of pesticides, should be used only when there is a need to effect an immediate reduction of a pest population to avert an impending medical problem or economic loss. In the previously discussed wasp problem, the use of chemical corrective measures was justified because of a need to immediately eliminate a human health hazard. The mechanical destruction of the nests was a preventive measure of sorts in that it was designed to prevent reestablishment of the colonies.

Implement safe and effective chemical controls. The timely and sustained implementation of nonchemical pest management techniques will significantly reduce the need to resort to the use of pesticides. When, however, as a result of inadequate or improper nonchemical measures or as a result of natural (or man-made) disasters, and migrating pest invasions, it becomes necessary to effect an immediate reduction of pest populations by chemical means, pest management personnel should select the chemical and method of application that will provide maximum results in terms of both pest eradication and environmental protection.

In order for pesticides to be used safely and effectively, they must be selected on the basis of the type of pests and their location. You must be knowledgeable of their development, habitats, and feeding habits. In many situations, it is more effective and safe to control pests in the larvae stage because they are more susceptible to chemicals, which requires less chemical to control them. If you know the habitats of pests you can direct control efforts to specific areas instead of having to treat an entire area just to insure the pests are affected, therefore, reducing hazards to nontarget organisms.

The feeding methods of pests is important in the selection of pesticides to be used in management programs. For chewing pests, stomach poisons applied to their food source would probably be more effective and less hazardous to other organisms in the area, especially those that are not chewing organisms; thus, you reduce the hazards to nontarget organisms. Contact poisons are very useful, and in many cases, are required, but they do present more hazard to nontarget organisms than the stomach poisons.

Now that the common bases for pesticide selection have been established, further environmental protection steps must be considered. These steps are the formulation and application of pesticides. Manufacturers conduct extensive research at an enormous expense to determine the proper formulation strength application rates for pesticides. This data, along with a great deal of other important information, as a matter of law, must be registered by the Environmental Protection Agency before the product can be marketed. The formulation and application procedures, as well as all use restrictions, are binding on all users of the product (including Government agencies). It is most important, therefore, that labeling instructions be strictly adhered to. This practice will insure maximum effectiveness of pesticide applications and minimum damage to the environment. Overdoses of pesticides rarely provide an increased kill of pests. They do tend to needlessly contaminate the environment, waste materials, and cause development of pest populations that are resistant to the chemical involved.

Exercises (425):

1. List the three steps that can be taken to reduce pesticide hazards in the environment.

2. What is the only way to accurately determine the requirements for pest management?

3. When should applied pest management programs be implemented?

4. If pest management programs must be implemented, what controls should be considered first?

5. Can preventive controls also serve as corrective measures?

6. Why are preventive controls normally preferred over corrective controls?

7. Implementation of nonchemical pest management techniques will significantly reduce the need of pesticides if they are ________ and ________.

8. Why may it become necessary to implement chemical control programs?

9. To reduce hazards presented to the environment, pesticides must be selected on the basis of the ________ of pests and their ____________.

10. How can maximum effectiveness and minimum hazards to the environment be insured when pests are to be managed by pesticides?

426. Define pesticide resistance and tolerance, state the types of physiological resistance, and specify the methods by which pests become resistant or tolerant to pesticides, and the methods of minimizing these problems.

Pesticide Resistance and Tolerance. As an Entomology Specialist, you must be very familiar with the terms "pesticide resistance" and "pesticide tolerance," because these terms are used frequently in most publications and discussions concerning pests and the controls to be used. You must also be knowledgeable of the types and methods in which pesticide resistance and tolerance are acquired and minimized, because you will be confronted with these topics throughout your career in the entomology field.

Pesticide resistance. Pesticide resistance can be defined as the ability of a pest population to withstand pesticide treatments that were generally lethal to earlier populations. It is often stated that insects develop resistance; however, this statement is inaccurate. Resistance is a trait that is inherited through a complicated genetic process by a few individuals within a reasonably large population. There is a tendency for this hereditary trait to be passed from parent to offspring. However, where a very few resistant specimens exist in a large population, probability dictates that only a very few resistant breeding combinations will occur, thus insuring that the trait will not develop throughout the population. Population alterations begin to occur, however, when the natural process of checks and balances is interrupted by the introduction to pesticides into the population. In the initial stages of the use of a particular pesticide to control a pest population, it can generally be said that a majority of the individuals are resistant. The susceptible individuals, upon exposure to the pesticide, die, while the resistant individuals survive (the weak perish; the strong survive). This process progresses to the point where the resistant strain, through its ability to survive, achieves a position of dominance in population reproduction. Continued use of the pesticide involved simply reinforces this dominance by the resistant individuals until finally, virtually all reproduction is being done by resistant individuals, thereby producing a resistant population. Once this occurs, further use of the pesticide will produce unsatisfactory results. The matter can be further complicated by cross-resistance, a process whereby exposure to one pesticide can produce populations that are also resistant to one or more other pesticides. This resistance to pesticides occurs in two forms, physiological and behavioristic.

Physiological resistance is the ability of an organism to physically negate the effects of the pesticide. Many facets of physiological resistance are not clearly understood. However, the following types of physiological resistance have been determined to exist:

- Slow absorption rate. Some members of a population absorb the poison too slowly to receive a lethal dose from a normal exposure.
- Storage. Some members of a population have the ability to store the poison in nonsensitive body tissues before it can kill.
- Excretion. Some members of a population are able to excrete the poison before it can kill.
- Detoxification. Some members of a population are able to detoxify the poison before it can kill. This detoxification is known to be the result of an enzymatic action. The harmless detoxification products are stored, excreted, or metabolized.
- Substituting biochemical systems. Death by pesticide poisoning, as from any other means, occurs as a result of blockage of vital life functions. This blockage is usually accomplished by the destruction or paralysis of vital organs. Some members of a

population are able to effect alternate accomplishment of the blocked function by other body systems until normal biophysical balance is restored.

Behavioristic resistance occurs in two forms:

- Habitat. A few members of a population may occupy a habitat different from that of the normal population. As a result, they are not exposed to routine pesticide applications.
- Avoidance. Some members of a population may be particularly sensitive to the pesticide. As a consequence, they will avoid contact with it.

Resistant members of a population, regardless of the type of resistance, tend to survive the pesticide application and rebuild a resistant population.

As the foregoing discussion illustrates, insects do not truly develop resistance to pesticides. The emergence of resistant populations occurs as a result of man-made alterations of the breeding population that allows resistant strains to become dominant, thus permitting massive reproduction of the resistant strains.

Pesticide tolerance. Pesticide tolerance can be defined as the ability of one or more pests within a pest population to withstand pesticide treatments that are lethal to others within the population.

Tolerance is another means by which certain members of a pest population may survive pesticide applications. Tolerance is acquired, whereas resistance is inherited. When an individual is exposed to one or more sublethal doses of pesticide, the body tends to develop a tolerance to that particular pesticide, making it possible for the individual to survive a future lethal dose. This tolerance, however, is not passed on to the offspring. Tolerance usually occurs in two different forms, physiological and behavioristic.

Physiological tolerance is the result of adjustments by body systems that prevent the normal harmful action of the pesticide.

Behavioristic tolerance is the behavioral adjustment the pest makes as a result of having undergone an unpleasant experience due to contact with a sublethal dose of the pesticide. This unpleasant experience causes the pest to recognize and tend to avoid the pesticide.

Now that the problems of resistance and tolerance have been discussed, the quesiton arises, "How can these problems be prevented or minimized?" One of the most effective solutions is to use pesticides only when absolutely necessary. This deprives insect populations of the exposure required to develop resistance and tolerance. When pesticides must be used, adhere strictly to label instructions. This will minimize underdoses and overdoses, both of which contribute significantly to resistance and tolerance.

Exercises (426):

1. List two methods for preventing or minimizing resistance and tolerance?

2. **Define pesticide resistance.**

3. **Define pesticide tolerance.**

4. **Behavioristic resistance occurs either by __________ or __________.**

5. **The primary difference between resistance and tolerance is that resistance can be __________ and tolerance is __________.**

6. **Describe the types of physiological resistance identified below:**
   a. **Slow absorption rate.**

   b. **Substituting biochemical systems.**

427. Distinguish between pesticide toxicity and hazard, state the method in which LD50 is expressed and determined, state the LD50 of identified pesticides, and define acute oral and dermal LD50.

Pesticide Toxicity and Hazard. Federal law requires that all manufacturers of pesticides place accurate and complete formulation and application instructions on their container labels. These instructions and other information on the labels must be based upon very extensive research which, in turn, must be reviewed and approved by the Environmental Protection Agency before the label is registered for use. During this research, the manufacturer must also establish toxicity levels for the pesticide being tested. This is the topic of this discussion.

Comparing toxicity and hazard. A number of people tend to use the terms "toxicity" and "hazard" synonymously when discussing pesticides. This practice is erroneous since *toxicity* implies the ability of a compound to cause death or injury, whereas *hazard* implies the likelihood that the compound will cause death or injury in a given situation. "Toxicity," therefore, represents a fixed quantity and "hazard" represents a variable quantity. For example, consider sodium monoflouroacetate (Compound 1080). This is an extremely deadly rodenticide that is capable of causing death in warm-blooded mammals when ingested in rather minute quantities. It is an extremely toxic compound whether locked in a steel vault or placed on a kitchen table where small children are present. The toxicity of the compound does not vary, regardless of its location. However, when the compound is left on a kitchen table in the presence of small children, it presents an infinitely greater hazard than when locked in a steel vault. In addition to the hazard to human beings, the hazard to other desirable animal and plant forms must be considered when selecting and applying pesticides. This can be a complicated process due to the fact that many pesticides with a low mammalian toxicity are extremely toxic to cold-blooded animals and vice versa. All these hazards can be minimized or eliminated by adhering to label instructions and practicing safety when handling or applying pesticides.

Determining and expressing LD50 values. Toxicity of pesticides is based principally upon the results of laboratory tests wherein rats, mice, and rabbits are exposed to carefully measured doses of pesticides. These animals are used because their bodies function much in the same way as human bodies. The test animals in the laboratory environment are carefully examined before the test to insure that all body functions are normal and that they are healthy animals. The ultimate objective of these tests is to determine the amount of pesticide that is lethal to 50 percent of the test group of animals. Accurate results require that all animals in the test group be as nearly identical, biologically and physically, as possible (same weight, sex, age, etc.).

In conducting the tests, rabbits weighing two kilograms (4.4 pounds) are used. Only 1 rabbit at a time is used in the beginning. This procedure permits the determination of an approximate amount of toxicant required before group testing, thus avoiding the needless killing of an excessive number of laboratory animals. Assuming that, during a given test series, it is determined that 500 milligrams of toxicant is lethal, but 490 milligrams is not lethal, the group test will begin with 10 animals, each of which will be exposed to 491 milligrams of toxicant. If more or less than 5 (50 percent) of the animals die, another test is conducted on another group of 10 animals with an appropriate adjustment in the dosage of toxicant. This process is repeated until 50 percent of a test group is killed by a measured dosage. Once the 50 percent fatality test is established, several more tests, using the same amount of toxicant on a different group of 10 animals each time, are conducted to validate the results. If consistent results are obtained throughout the validation tests, the results are considered to be an accurate determination of the relative toxicity of the pesticide being tested. This toxicity is expressed in terms of milligrams of pesticide per kilogram of body weight that produces a 50 percent kill of the test groups. This is figuratively expressed as LD50 (lethal dose for 50 percent kill rate). The following mathematical process is used to arrive at the LD50 value, assuming that 492 milligrams of toxicant were required to kill 50 percent of the test animals:

$$\text{Toxicity} = \frac{\text{milligrams of toxicant required to kill 50\% of test animals}}{\text{kilograms of body weight per animal}}$$

$$\text{LD50} = \frac{492}{2}$$

$$\text{LD50} = 246 \text{ mg/kg}$$

From this test we have determined that the pesticide being tested has an LD50 value of 246 mg/kg, but what does this mean in relation to the hazards subjected to humans and the environment in general? If we analyze the test process, we can readily see that the results are statistical quantities relating to a large group of test animals. Such results are useful in determining relative toxicities of pesticides and *educated* estimates to the effects on any given individual. The only way to determine the amount of toxicant required to kill any given individual is to poison him to the point of death (an undesirable process). Thus, we can accurately conclude that an established LD50 value is not necessarily required to kill a given individual, since varying physiological functions produce varying degrees of susceptibility in different individuals.

Relationship of LD50 values and pesticide classification. LD50 values are useful in classifying pesticides into groups according to their relative toxicities as follows: *Highly toxic* = 0–50 mg/kg, *moderately toxic* = 50–500 mg/kg, *low-order toxicity* = 500–5000 mg/kg and *comparatively free from danger* = 5000 + mg/kg.

As you can see, the lower the numbers, the more toxic a pesticide is. This is because a lower number indicates that a smaller amount of toxicant is required to cause death.

Toxicity is usually expressed in terms of exposure routes. The two common terms are "oral toxicity" which relates to ingestion of the toxicant by mouth and "dermal toxicity" which relates to absorption of the toxicant through the skin. Most pesticides can be absorbed through the skin. Dermal toxicity values are based upon the quantity of toxicant that will kill 50 percent of the test animals when absorbed through the unabraded skin. Oral and dermal toxicities of a given toxicant are rarely identical. Usually, dermal exposure is less hazardous than oral exposure. However, some chemicals are almost as dangerous when left in contact with the skin as they are when ingested and, in no case should any toxicant be left in contact with the skin, especially if the toxicant is in its concentrated form.

The relationship of oral and dermal LD50 values of pesticides are illustrated in table 1-2.

It is apparent that mankind's traditional practice of environmental exploitation must now be modified. From the beginning of time until very recently, man has pursued his socioeconomic endeavors on the premise that the earth's natural resources were inexhaustible and that the earthly environment was

TABLE 1-2

COMPARISON OF ACUTE ORAL AND DERMAL TOXICITIES

Insecticide	Acute Oral Toxicity to Female Rats LD_{50} (Mg/kg)	Acute Dermal Toxicity to Female Rats LD_{50} (Mg/kg)
HIGHLY TOXIC INSECTICIDES - Acute oral toxicity to rats - 1-50 mg/kg		
ethyl parathion	3.6	6.8
dioxathion (Delnav)	23	63
methyl parathion	24	67
dieldrin	46	60
MODERATELY TOXIC INSECTICIDES - Acute oral toxicity to rats - 50-500 mg/kg		
dichlorvos (DDVP, Vapona)	56	75
toxaphene	80	780
chlorpyrifos (Dursban)	82	202
propoxur (Baygon)	86	2400
lindane	91	900
Paris green	100	2400
DDT	118	2510
chlordecone (Kepone)	125	2000
fenthion (Baytex, Entex)	245	330
dimethoate (Cygon)	245	610
heptachlor	162	250
diazinon	285	455
naled (Dibrom)	250+	800+
chlordane	430	690
LOW-ORDER TOXICITY INSECTICIDES - Acute oral toxicity to rats - 500-5000 mg/kg		
carbaryl (Sevin)	500	4000
trichlorfon (Dipterex)	560	2000
malathion	1000	4444
rabon (Gardona)	1125	4000
ronnel (Korlan)	2630	5000
Mirex	3000	2000
INSECTICIDES COMPARATIVELY FREE FROM DANGER - Acute oral toxicity to rats - 5000+ mg/kg		
methoxychlor	6000	6000
Abate	13,000	4000

indestructible and, in fact, inalterable at the hands of man. Now, largely due to the burgeoning world population and rapidly advancing industrialization, we have been compelled to face the stark reality of natural resource depletion and increasingly harmful environmental pollution.

This text has discussed the interdependence of all elements, living and nonliving, in our environment. Human beings are an integral part of this environment and are just as dependent on the other elements of the environment as any other organism. Therefore, in order to insure our own continued existence and state of well-being, we must not commit acts that could ultimately result in the destruction of any essential element of our environment.

We, as pest managers, have a great responsibility resting on our shoulders. As you have seen, pesticides are an essential tool in the control of medically and economically important pests, and will remain so for the foreseeable future. It has been demonstrated, on the other hand, that the improper and indiscriminate use of pesticides can exert a very destructive influence on our environment. It is our responsibility to use pesticides only to the extent necessary and to insure that we use them in such a way as to prevent unnecessary deleterious effects on the environment. We must make the greatest possible use of nonchemical methods to manage pest populations.

Exercises (427):

1. Define hazard.

2. Define toxicity.

3. Explain what the term "LD50" means.

4. The toxicity range for moderately toxic pesticides is __________ to __________ mg/kg.

5. Briefly explain the method for determining the relative toxicity of a pesticide.

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6. What is the primary difference between oral toxicity and dermal toxicity?

7. Dermal exposure is usually __________ (more/less) hazardous than oral exposure.

8. Paris green is __________ toxic upon oral exposure but is considered to be a __________ toxic compound upon dermal exposure.

CHAPTER 2

Pesticide Dispersal Equipment

SINCE 1940, THE control of insects has been revolutionized by two outstanding developments; first, the production of phenomenally effective pesticides such as the chlorinated hydrocarbons, organophosphates, and carbamates, and second, the parallel development of new types of pesticide equipment. Many types of application equipment, such as the ultra-low volume insecticide generators, have become available only during the past several years, so that pest managers need to examine their current needs to profit from the new developments.

Hundreds of different kinds of sprayers, dusters, aerosol generators, and other devices have been designed, manufactured, and marketed. The selection of the best equipment for a pest management program is of great importance since pesticide application problems may seriously affect a program. The safe and efficient dispersal of pesticides to control insects and other arthropods affecting health, morale and the economy, requires a knowledge of pesticide application equipment and training in the method of applying these pesticides.

This chapter identifies and describes the uses of equipment utilized by Air Force pest managers; outlines operational and maintenance responsibilities and procedures; and describes the methods used for regulating dispersal rates and calibrating pesticide dispersal equipment.

2-1. Types and Uses of Equipment

A certain item of equipment can be used in several different types of pest management programs. However, there is usually one item of equipment that will be more efficient and safe for particular program than other types of equipment. The purpose of this section is to provide you with the basis for selecting pesticide dispersal equipment and help you to identify the various types and uses of pesticide dispersal equipment commonly used in Air Force pest management programs.

428. Identify factors that are involved in selecting pest management equipment.

Basis for Selecting Equipment. Before the actual selection of pest management equipment, you must consider all the factors that are outlined in Volume 2, Chapter 2, objectives 220, 222 through 226; and objectives 416, 422, 424, and 425 in Chapter 1 of this volume.

Following the reveiw of these objectives, it is obvious that there are many factors that must be considered in selecting equipment, and yet, there are more.

The remaining factors that are used as basis for selecting equipment are dependent upon:

- Availability.
- Effectiveness.
- Safeness.
- Cost.
- Durability of the equipment.

Availability. When selecting equipment to be used for a particular pest management situation, the selection should be based upon the equipment that is presently available, providing it will do the job effectively and safely. However, there may be some pest management situations that will require special equipment for treatment. In this case, you should check the Table of Allowance (TA 489, Part C) to see if the equipment desired is listed and authorized for your section. Whether the equipment is authorized or not, you must prepare and submit sufficient justification as to why this equipment is required.

Effectiveness. This one of the primary factors that must be considered when selecting equipment. The equipment selected must be the most effective for accomplishing the job that is required and it must be the safest.

If the equipment required is not presently available and you desire to obtain it, you must consider the frequency of required use and the effectiveness and safeness of the equipment to be used in other pest management programs. After these facts have been considered and you are convinced that this equipment is necessary, you must prepare and submit sufficient justification to convince the higher levels of management.

Safeness. This is the most important factor to be considered when selecting equipment for pest management programs. Regardless of how effective the equipment might be for a pest management situation, if it is unsafe, do not use it.

Cost. With today's austere operational budget, it is essential that the cost of the equipment be considered when selecting equipment to be purchased. The equipment that you select should be low in cost initially and should be cheap to maintain.

Durability. Durability is one of the factors that should be considered when considering the total cost of the equipment. An item of equipment may have a low purchase price which would be low in cost initially, but if the equipment is not durable, the overall cost may be great due to the expenditures incurred for maintenance or possibly having to replace it.

Remember, the effective use of pesticides depends upon the availability of efficient and durable dispersal equipment. When asked to select equipment, you should select it on the basis of its being the most effective and the safest for the job to be accomplished.

Exercises (428):

1. Why is the identification of the type of pest important in selecting control equipment?

2. Describe the effects that environmental conditions may have on the selection of equipment.

3. The equipment you select must be the most __________ for accomplishing the job that is required and it also must be ______________ .

4. Your selection should be based on that which is presently ______________ and provided that it will do the job ____________ and ____________ .

5. The most important factor to consider in selecting equipment is that the equipment must be ______________ .

6. The equipment you select should be low in __________ initially and should be __________ to maintain.

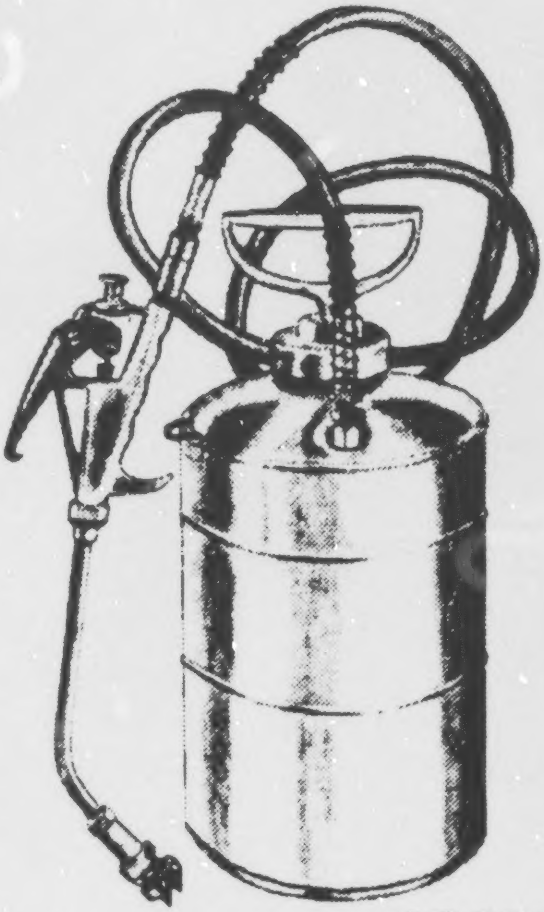
7. If the equipment is not ____________ the overall cost may be great.

427. Match listed items of manual sprayers with the uses that are described.

Types and Uses of Manual Sprayers. Now that you are aware of the many factors that must be considered when selecting equipment, you must know the types and uses of manual sprayers that are available for use in implementing safe and effective pest management programs.

Generally speaking, there are four manually operated sprayers that are commonly used in Air Force pest management programs. There are compressed air sprayers, aerosol dispensers, siphon atomizers, and pistol sprayers. There are three other types of manual sprayers that are commonly used within and around the home that you should be familiar with. These are knapsack sprayers, trombone sprayers, and garden hose sprayers.

Compressed air sprayers. This item of equipment (fig. 2-1) is the mainstay of most pest management programs. It is used particularly to apply residual



CF-051

Figure 2-1 Compressed air sprayer (typical)

sprays for mosquito, fly, and flea control; larvicides for mosquito and fly control; spot treatments and crack crevice treatments for cockroaches, ants, ticks, and many other types of household insects; and small area treatments outside to control fleas, ticks, and other pest species. Much care must be taken in selecting high quality equipment.

Aerosol dispensers. The aerosol dispenser "bug bomb" is more widely used by the general public than any other type of pesticide applicator.

There are two basic types of aerosol dispensers; the first being a small low-pressure, disposable dispenser (fig. 2-2) that is used in the average household and the second being a larger, high-pressure, refillable dispenser (fig. 2-3) that is used by many professional pest managers. Both types are used as space sprays for killing flying insects and to flush pests from harborage areas.

One of the most common types of aerosol dispensers for flies and mosquitoes contains pyrethrum, allethrin, or synthetic pyrethrum for quick knockdown, a synergist such as piperonyl butoxide, and a synthetic insecticide such as methoxychlor for the kill. Other aerosol dispensers contain different chemicals to kill cockroaches, ants, and other household insects. One bomb, manufactured to throw a fine stream for 10 to 20 feet, is used to spray nests of stinging insects such as wasps and hornets from a safe distance.

Siphon atomizers. The siphon atomizer or *flit gun,* is a familiar household item. There are two types of siphon atomizers, one type being an intermittent atomizer without an interchangeable nozzle and the other type being a continuous atomizer with an interchangeable nozzle.

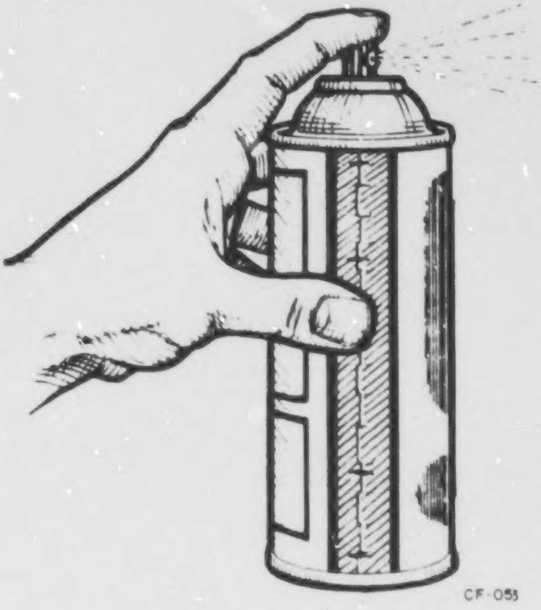


Figure 2-2. Aerosol disperser (small).

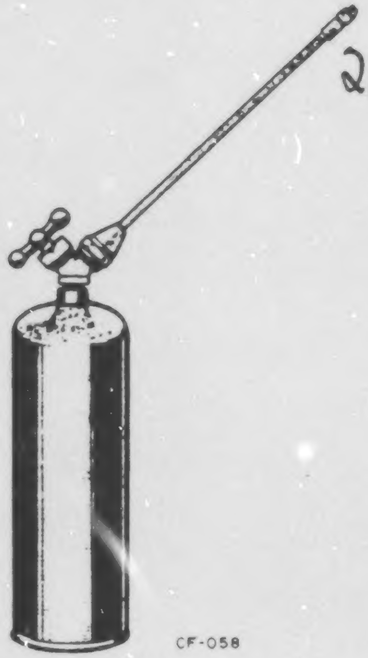


Figure 2-3. Aerosol disperser (large).

As a general rule, these sprayers are designed to control flying insects, particularly flies and mosquitoes. In recent years, aerosol dispensers have practically supplanted this type of sprayer. Pneumatic paint sprayers operate on the same basic principle as the *flit gun,* but are powered by an electric or gasoline motor. They are sometimes used for space spraying in larger buildings where hand equipment is inadequate.

Pistol sprayers. The pistol sprayer (fig. 2-4) is much like the *gun* used for oiling automobile springs. A fine, solid stream of pesticide is produced by pulling the trigger on the gun. It is especially valuable when small amounts of solution or emulsion need to be applied to cracks and crevices in buildings for cockroach and ant control. Pistol sprayers are especially designed to resist corrosive chemicals. A plastic container has been used to apply small amounts of insecticide to collections of water in small containers, such as tin cans, saucers under flower pots, old tires, or water drums. They were used extensively on the *Aedes aegypti* eradication program and may play a part in many urban mosquito control programs.

Knapsack sprayers. Knapsack sprayers are used chiefly in treatment of small gardens, and to a lesser extent for mosquito larviciding in very swampy areas where it is difficult to pump up a compressed air sprayer. Adjustable nozzles are usually standard equipment on these sprayers.

Trombone sprayers. Some trombone sprayers can spray a stream of pesticide 20 to 30 feet vertically. Trombone sprayers used around buildings usually have the insecticide in a pail, as shown in figure 2-5, while other types used in mosquito larviciding have the pesticide in a tank carried on the back of the pest controller.

Garden hose sprayers. Although the primary use of the garden sprayer (fig 2-6) is for garden, lawn, and shrubbery insects, it can be used to control fleas, ticks, and chiggers in yards, or to apply residual insecticides near the base of buildings to keep out insects such as cockroaches, earwigs, or mites. Although this type of sprayer is very useful for many householders, it is limited to the area that can be reached with the garden hose

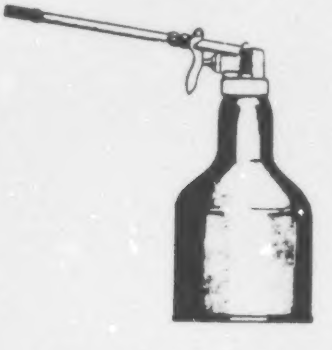


Figure 2-4. Pistol sprayer (typical).

Exercises (429):
Match the use of applicator in column A with manual applicators in column B.

Column A
Use of Applicators

____ 1. Used around buildings with insecticide in a pail.
____ 2. Used for applying small amounts of solution to cracks and crevices in buildings for cockroaches and ant control.
____ 3. Used to apply residual sprays for mosquito, fly, and flea control.
____ 4. Primarily used for garden, lawn, and shrubbery insects.
____ 5. Used for treatment of small gardens.
____ 6. Designed to control flying insects.
____ 7. Most frequently used for spray application in households.

Column B
Applicators

a. Compressed air sprayers.
b. Aerosol dispensers.
c. Syphon atomizers.
d. Pistol sprayers.
e. Knapsack sprayers.
f. Trombone sprayers.
g. Garden hose sprayers.

430. Match listed items of manual dusters with the uses that are described.

Types and Uses of Manual Dusters. There are several types and variations of manual dusters, but only seven will be described in this objective. You must be capable of recognizing these items of equipment and be knowledgeable of their uses because they will be referred to quite often in day-to-day Air Force pest management programs and pest management literature.

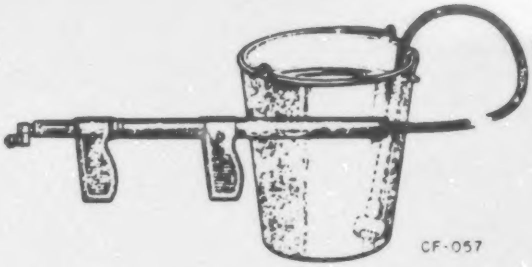


Figure 2-5. Trombone sprayer (typical).

Hand shakers. The hand shaker (fig. 2-7) is ideal for placing pesticides on high or difficult-to-reach areas. A large shaker which holds 9 pounds of insecticidal dust has been used for dusting exposed rat runs along the base of walls and foundations to kill rat ectoparasites such as the oriental rat fleas which transmits organisms that cause plague and murine typhus. Small 1- or 2-pound shakers may be used for dusting rat runs not accessible to the large shaker.

Hand bellows. This duster (fig. 2-8) is used where careful placement and neatness are essential, dusting crevices where cockroaches and silverfish hide, or placing a small amount of anticoagulant dust in voids for mouse control.

Bulb dusters. The bulb duster (fig. 2-9) is also designed for careful indoor dusting operations. Its uses are basically the same as the hand bellows, but some operators prefer the bulb duster as opposed to the hand bellows.

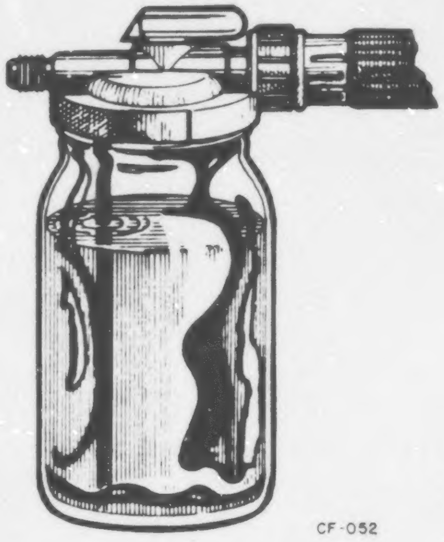


Figure 2-6. Garden hose sprayer (typical).

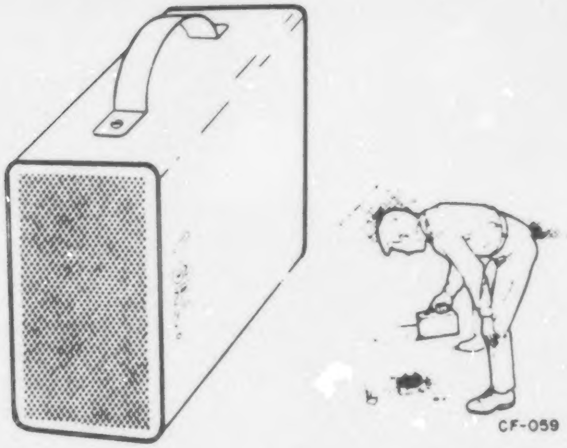


Figure 2-7. Hand shaker (typical).

Hand plunger dusters. The hand plunger duster (fig. 2-10) is suitable for applying patches of malathion and carbaryl dust outdoors or in outbuildings for rodent ectoparasite control. This duster can also be used to apply pesticides to control many other types of pests such as chiggers, mites, and ticks.

Rotary hand dusters. The rotary hand duster (fig. 2-11) is used effectively for applying pesticides for controlling fleas, ticks, and other ectoparasites around premises, and for applying dusts as mosquito larvicides. Most rotary hand dusters are sold with a fan-shaped tip to give a broad band of dust for mosquito larviciding or for area treatment in flea, tick, or chigger control.

Foot pump dusters. The foot pump duster (fig. 2-12) is designed for applying calcium cyanide to rat burrows to kill both rats and rat ectoparasites. This equipment is useful for applying dust to rodent burrows and other inclosed harborages.

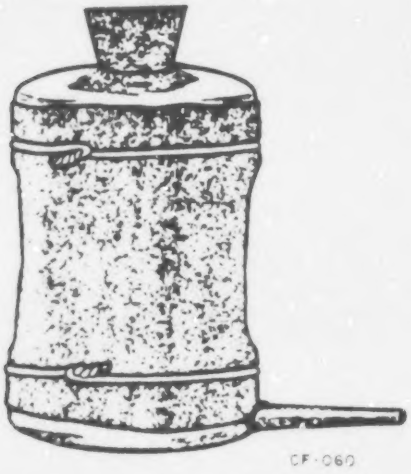


Figure 2-8. Hand bellows (typical).

Granular spreaders. There are two basic types of spreaders commonly used in Air Force pest management programs; one is known as the grass seeder (fig. 2-13), and the other is a push type fertilizer spreader. Both types can be used effectively in applying pesticide granules over small outdoor areas to control many insect larvae and pest vegetation.

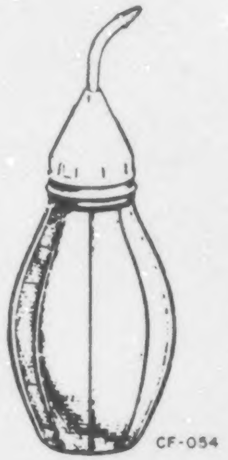


Figure 2-9. Bulb duster (typical).

Exercises (430):

Match the use of dusters in column A with the type of manual dusters in column B.

Column A
Use of Manual Dusters

____ 1. Used effectively in controlling fleas and ticks around premises and dust for larvicide.
____ 2. Ideal for placing pesticides on high or difficult-to-reach areas.
____ 3. Used outdoors to distribute pesticides to control insect larvae and pest vegetation.
____ 4. Used where careful placement and neatness are essential.
____ 5. Used to apply calcium cyanide to rat burrows.
____ 6. Suitable for applying patches of malathion and carbaryl dust outdoors or in outbuildings.
____ 7. Designed for careful indoor dusting operation.

Column B
Manual Dusters

a. Hand shakers.
b. Hand bellows.
c. Bulb dusters.
d. Hand plunger dusters.
e. Rotary hand dusters.
f. Foot pump dusters.
g. Granular spreaders.

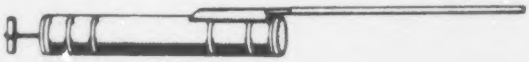


Figure 2-10. Hand plunger buster (typical).

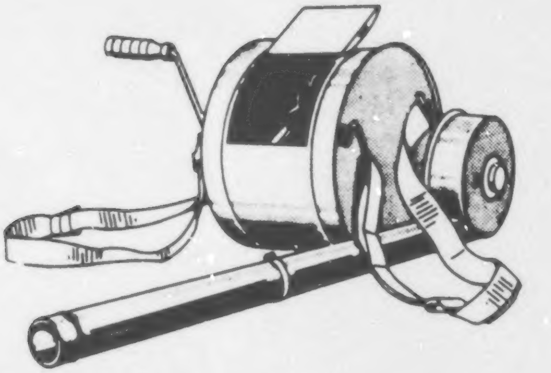


Figure 2-11. Rotary hand duster (typical).

431. Match listed items of portable powered equipment with the uses that are described.

Types and Uses of Powered Equipment (Portable). Portable powered equipment has improved pest management programs tremendously, because it has permitted access to areas that were not accessible with larger items of equipment and at the same time, has reduced the amount of time required for treatment. These items of equipment, along with their common uses, will be identified with this objective. For text purposes, the term "portable" applies to items of equipment that can be carried easily from one place to another by one or two individuals.

Backpack mist-dust blowers. The backpack mist-dust blower (fig. 2-14) is very light in weight and can easily be carried by one individual. Many models of this equipment can be used to apply liquids, dusts, and granules. This item of equipment is very useful in applying pesticides to small outdoor areas and areas that are inaccessible by larger mist-dust blowers. This equipment can be used for applying residuals to trees, shrubs, and grasses for controlling pests of vegetation, ants, earwigs, and ectoparasites such as fleas, lice, ticks, and mites. The backpack mist-dust blower is also used in larviciding programs for mosquitoes, flies, and beetles and can be used to treat exterior surfaces of buildings to control flying insects such as flies, mosquitoes, wasps, and hornets, and to control spiders.

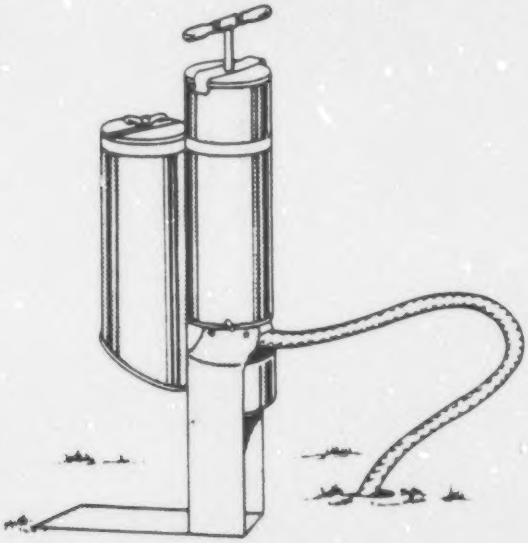


Figure 2-12. Foot pump duster (typical).

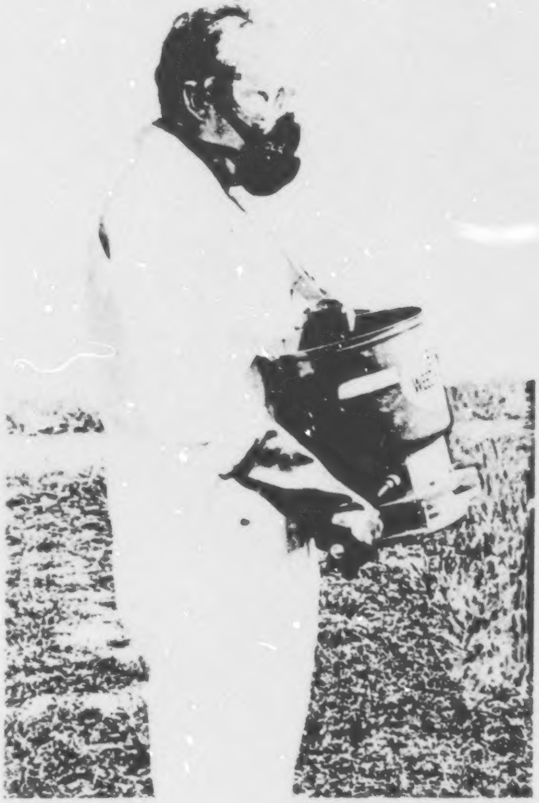


Figure 2-13. Granular spreader (typical).

Hand-carried thermal fog generators. This item of equipment is designed to disperse only solution formulations and is used primarily for small localized outdoor space treatments to control flying insects. a typical hand-carrier thermal fog generator is illustrated in figure 2-15.

Hand-carried ultra-low volume generators (ULV). This hand-carried ultra-low volume generator (fig. 2-16) is primarily designed to disperse technical grade or very highly concentrated pesticide formulations. This item of equipment can be used for space treatments and residual treatments of small indoor and outdoor areas. Its principal use outdoors is for mosquito adulticiding programs and its principal use indoors is for controlling structural pests.

Frame-mounted hydraulic sprayers. This type of equipment is designed to disperse emulsion and solution formulations as sprays. This frame-mounted hydraulic sprayer (fig. 2-17) is not efficient for dispersing suspension formulations because it does not have an adequate agitator for suspensions. Due to its versatility and ease in handling and maneuverability, it is probably used more often than any other type of powered equipment in normal day-to-day pest management operations. This item of equipment is especially useful in soil poisoning operations for controlling termites; applying residuals to trees, shrubs, and grasses for controlling pests of vegetation and ectoparasites; applying residuals to exterior surfaces of buildings and beneath them to disease vectors and venomous arthropods; applying herbicides to control pest vegetation; and applying larvicides to soil and water areas for controlling beetle, fly, and mosquito larvae.

Exercises (431):
Match uses in column A with the type of equipment in column B.

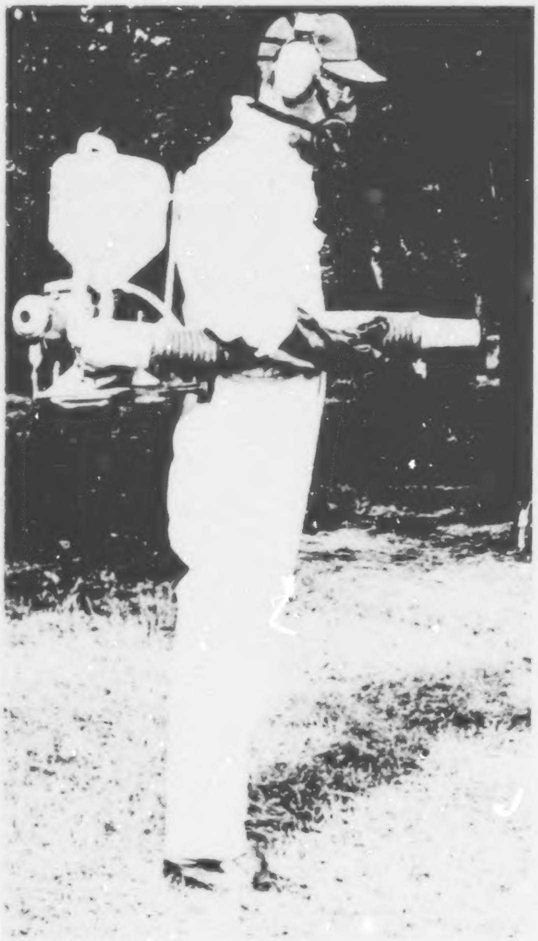


Figure 2-14. Backpack mist-dust blower (typical)

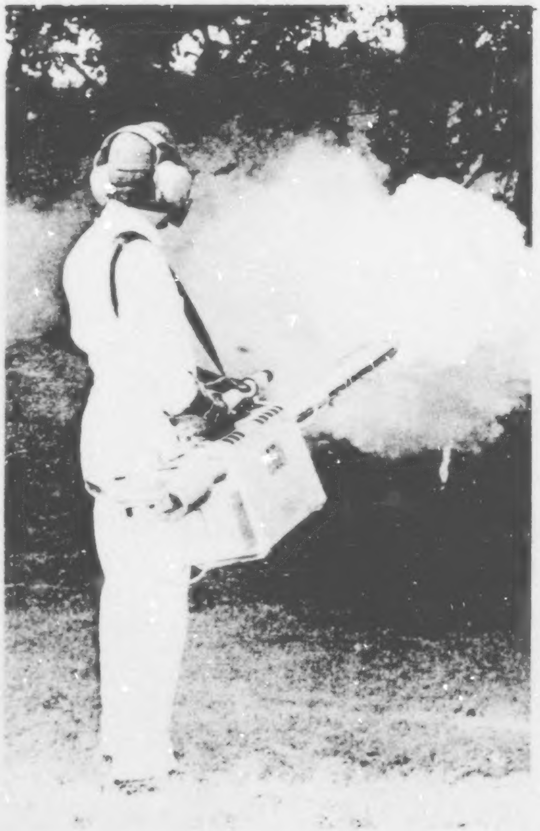


Figure 2-15. Hand-carried thermal fog generator (typical).

Column A *Uses*	*Column B* *Type of Equipment*
____ 1. Designed to disperse technical grade or highly concentrated formulations.	a. Backpack mist-dust blowers.
____ 2. Designed to disperse only solution formulation.	b. Hand-carried thermal fog generators.
____ 3. Designed to disperse emulsions and solution formulations.	c. Hand-carrier ultra-low volume generator.
____ 4. Lightweight unit for dispersal of dusts.	d. Frame-mounted hydraulic sprayers.

432. Match listed items of nonportable powered equipment with the uses that are described.

Types and Uses of Powered Equipment (Nonportable). Nonportable powered equipment as described in this text is equipment that must be transported by some type of vehicle due to the weight or awkwardness of the equipment. The types of nonportable powered equipment are as varied as the portable powered equipment. Although the designed uses for each type are basically the same, the nonportable equipment is designed for treating larger areas in a very short time.

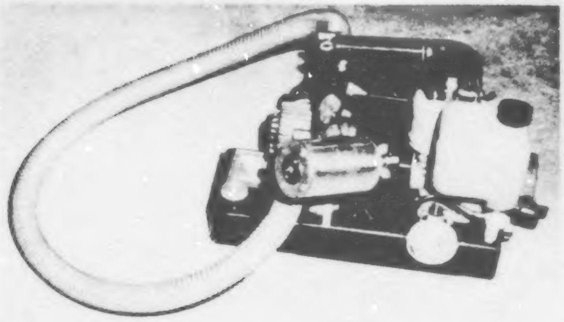


Figure 2-16. Hand-carried ULV generator (typical).

Nonportable mist-dust-blowers. This type of powered equipment is manufactured in many forms for different pest management programs. Some are designed to be mounted on trailers and others for trucks of various sizes; some are designed to rotate on a rail base, and others that are mounted on a fixed base.

This item of equipment can disperse liquid, dust, and granule formulations and is used for treating large outdoor areas by applying pesticidal mists and dusts to trees, shrubs, and grasses for controlling pests that attack vegetation and the ones that harbor in vegetation. The nonportable mist-dust blower (fig. 2-18) is also used for applying residual mist to exterior surfaces of buildings for controlling adult flying insects, and venomous arthropods, and for applying larvicides to turf and water for controlling beetle, fly, and mosquito larvae.

Trailer-mounted hydraulic sprayers. The trailer mounted hydraulic sprayer is used to apply all types of liquid formulations as sprays. There are two basic types of this sprayer. One is the boomless sprayer and the other is the boom sprayer; however, some are designed to be used either way, as illustrated in figure 2-19.

a. Boomless hydraulic sprayer. The boomless hydraulic sprayer is designed to disperse pesticides through a single nozzle and is used for applying residual sprays to trees and shrubs for controlling pests of vegetation; applying residuals to buildings, refuse containers, and sanitary landfills for controlling flies and mosquitoes; applying larvicides to fly and mosquito breeding areas; applying herbicides as spot treatments for controlling pest vegetation around sign posts, utility poles, storm drains, and gutters; in cracks of sidewalks and streets, and in improved turf areas. The boomless hydraulic sprayers are also used to apply herbicides in ditchbank, irrigation and drainage systems; basal-bark, stump, and fence-row treatments.

b. Boom hydraulic sprayer. The boom hydraulic sprayer is designed to disperse pesticides through several nozzles that are contained in the boom. This allows the pesticide to be applied at an even rate over a

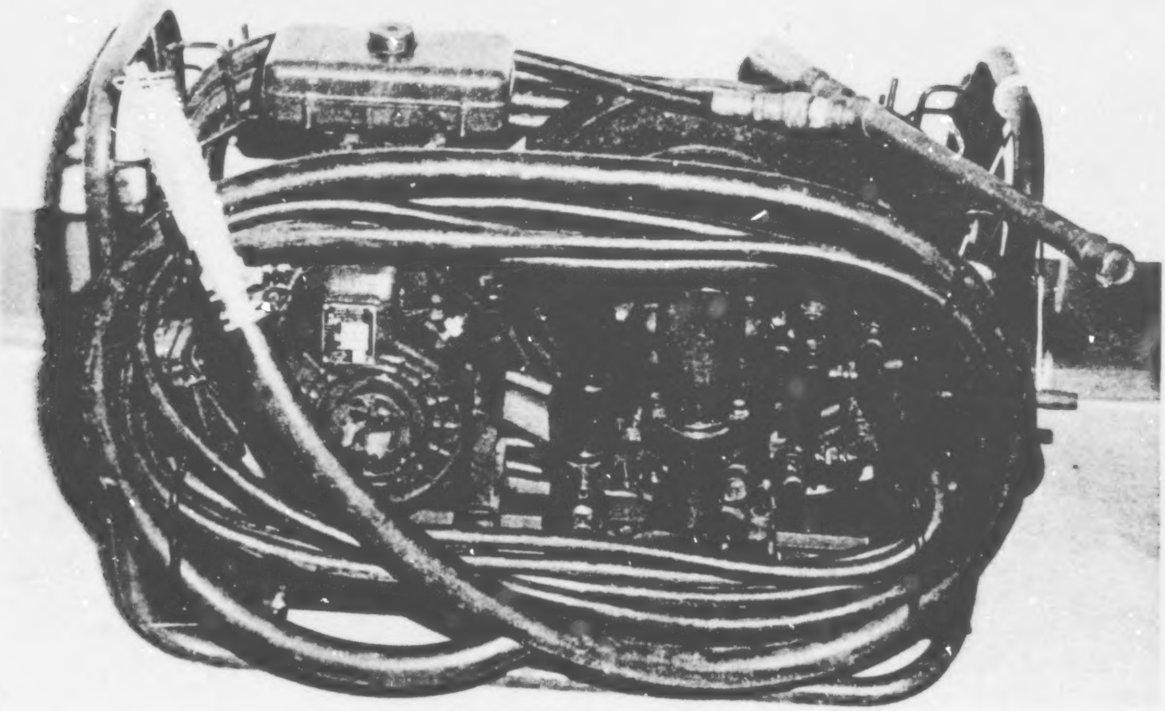


Figure 2-17. Frame-mounted hydraulic sprayer (typical).

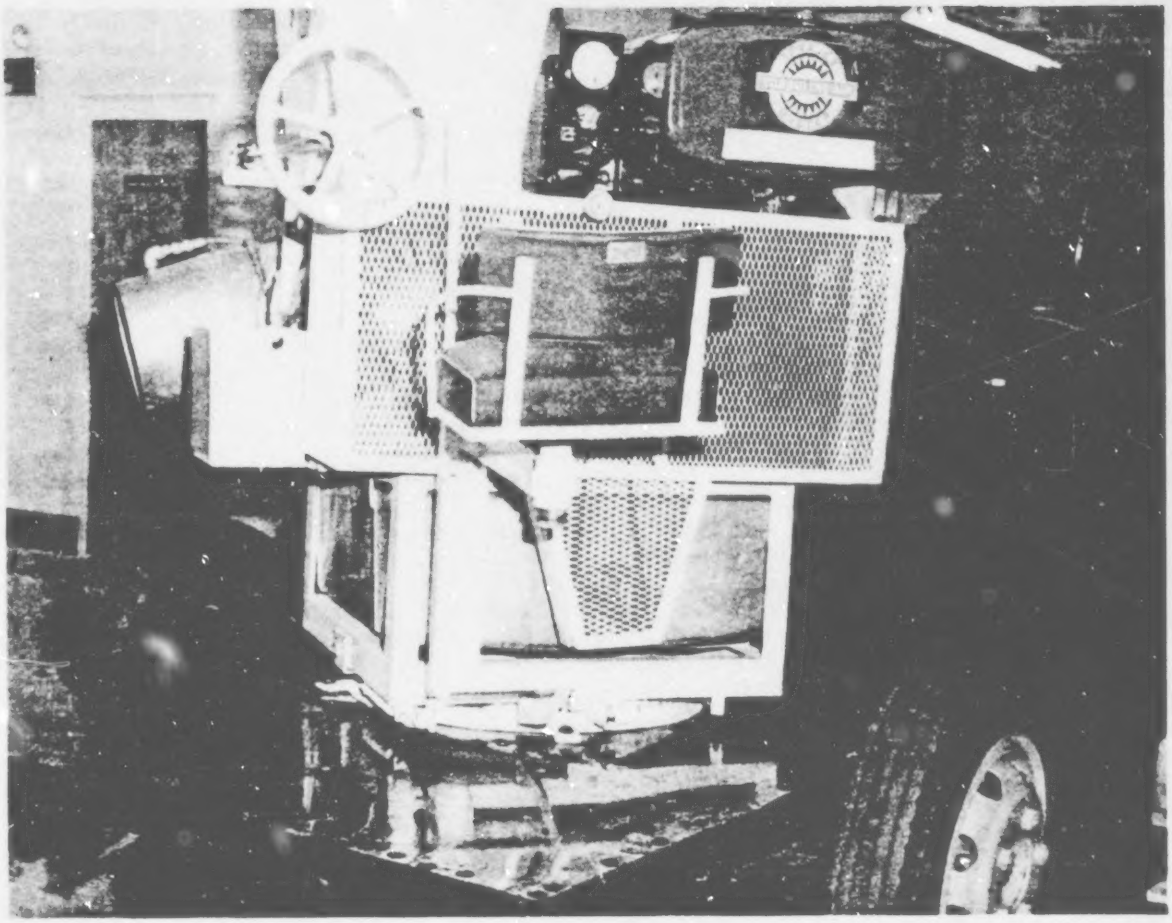


Figure 2-18. Nonportable mist-dust blower (typical).

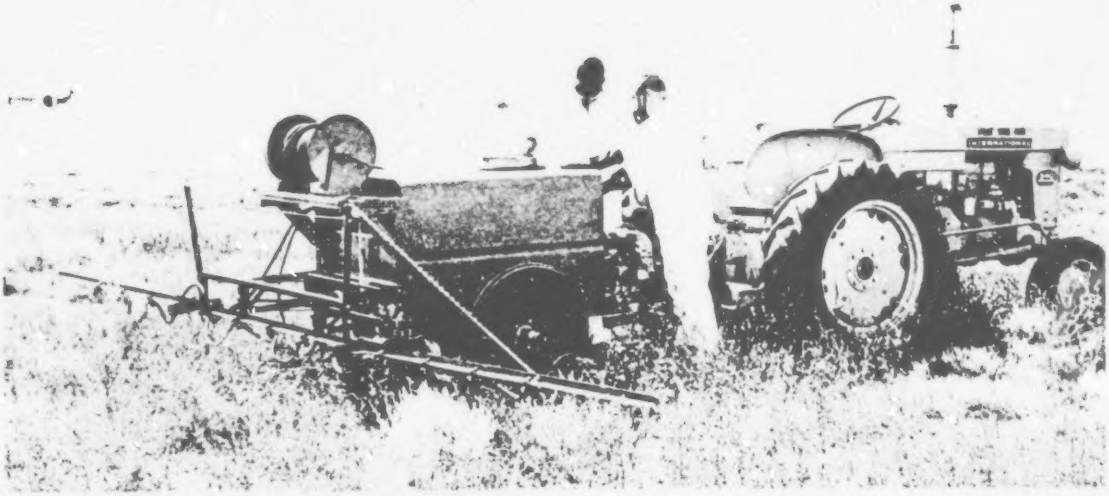


Figure 2-19. Trailer mounted hydraulic sprayer (typical).

wide area of soil and turf in a single swath. This type of hydraulic sprayer is used in soil poisoning treatments in the prevention of termite infestations and seed germination. It is also used to apply pesticides over turf and grass areas to control larva and adult pests of vegetation, fly larvae, and existing pest vegetation.

Nonportable thermal fog generators. The nonportable thermal fog generator (fig. 2-20) breaks up the insecticide into an aerosol by means of hot exhaust gases. This item of equipment is used in space treatment programs to control flying insects, especially mosquitoes, in large outdoor areas. It is especially advantageous for use in areas where wide swaths must be relied upon to kill flying insects several hundred feet away. A solution formulation is the only type of formulation that can be dispersed with this equipment.

Nonportable mechanical aerosol generators. The nonportable aerosol generator (fig. 2-21) produces an aerosol that is similar to a fog by means of the insecticide being forced by a large volume of air through special nozzles. This type of equipment is designed to disperse both solution and emulsion formulations for space treatment programs to control flying insects, especially mosquitoes. Due to its capability of producing an aerosol similar to a fog without being thermally produced, it is often referred to as a "cold fogger."

The advantages of this item of equipment as compared to the nonportable thermal fog generator are that there is no visible cloud of insecticide to create traffic hazards, there is no heat applied to cause thermal breakdown of the insecticide, and emulsions can be used as effectively as solution which could result in a savings of solvent costs.

Nonportable ultra-low volume generators (ULVs). During the past several years, thre has been a rapid and dramatic increase in the use of undiluted insecticides applied at extremely low dosage to control insects of medical and economical importance which employs the use of a ULV generator.

The nonportable ultra-low volume generator (fig. 2-22) may replace or supplement the use of thermal and cold fog generators in years to come.

In the ULV method of application, the technical insecticide is atomized into millions of tiny droplets, the majority varying from 5 to 50 microns (from 1/5000 to 1/500 of an inch) in diameter, and dispersed evenly over the treated area. This technique has resulted in substantial savings in money and time due to the reduced amounts of insecticide that are required and eliminating the diluent, mixing, and transport of larger volumes of diluted formulations.

It is reported that ULV generators which disperse cold aerosols are more effective against adult mosquitoes than the thermal fog generators which disperse thermal aerosols. ULV applications frequently use less insecticide per acre treated than do cold or thermal foggers or misters, resulting in savings in insecticide cost, elimination of diluents, and time for loading or travel of equipment. Other advantages of ULV aerosols are that they do not produce dense fogs—as do thermal fogs—that constitute a traffic hazard and might result in deaths of children running or bicycling into the fog. The nonportable ULV generator is relatively small. Its insecticide tank is usually of the 5 to 10 gallon size, and it is usually mounted on a small vehicle such as a 1/2-ton pickup truck. By contrast, the nonportable thermal fog generator as well as the nonportable aerosol generator is much larger and heavier; its insecticide tank may contain 25 to 200 gallons or more, and it is usually mounted on a larger vehicle, such as a 1- to 3-ton truck.

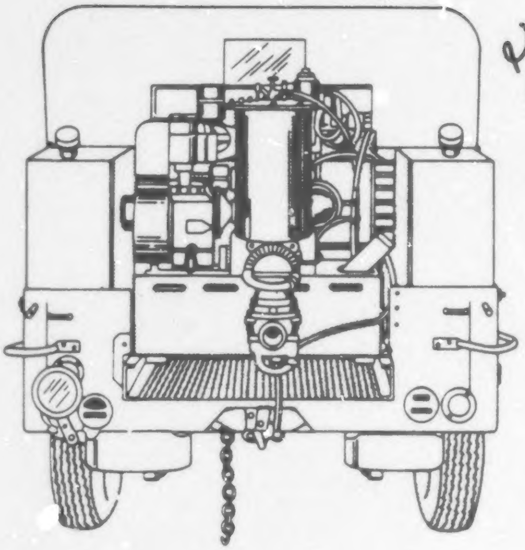


Figure 2-20. Nonportable thermal fog generator (typical).

On the other hand, ULV applications may be less effective than thermal fogs in heavy vegetation. In some areas, car spotting, or damage to automobile finishes, has occurred because of the corrosive properties of some of the insecticides, but generally only when large droplets (greater than 100 microns, the diameter of a human hair) are present in the spray. Greater care must be taken in handling the concentrated or technical insecticides used in the ULV method because of increased degree of exposure to toxic concentrations of the chemical, particularly by spillage during loading operations, than with the diluted fuel oil formulation used in the thermal foggers and cold foggers.

Another type of ULV dispersal equipment, similar to the one illustrated in figure 2-23, is authorized for use in large warehouses and storage areas in treating for stored products pests.

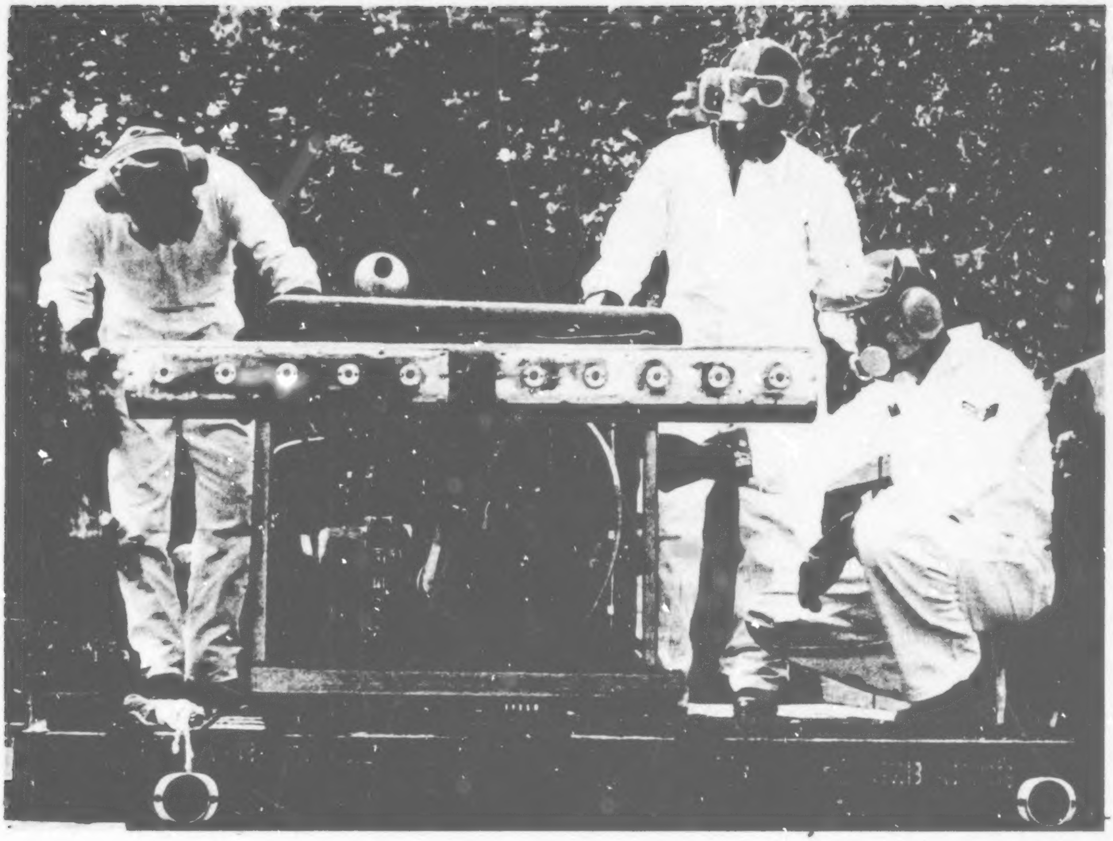


Figure 2-21. Nonportable mechanical aerosol generator (typical).

Exercises (432):
Match uses in column A with powered equipment in column B.

Column A *Uses*	*Column B* *Powered Equipment*
___ 1. Used to apply pesticide over a wide area at an even rate.	a. Nonportable mist-dust blowers.
___ 2. Used to apply undiluted insecticides at extremely low dosage.	b. Boomless hydraulic sprayer.
___ 3. Used to apply mists and dust to trees, shrubs, and grass.	c. Boom hydraulic sprayer.
___ 4. Used to apply liquid formulations through single nozzle.	d. Nonportable thermal fog generators.
___ 5. Used to disperse solution or emulsion formulation for space treatment to control flying insects.	e. Nonportable mechanical aerosol generators.
___ 6. Used to break up insecticides by hot exhaust gases.	f. Nonportable ultra-low volume generators (ULV).

433. Specify the types and uses of fumigation equipment and supplies.

Types and Uses of Fumigation Equipment and Supplies. There are many items of equipment and supplies that are required for fumigation programs. However, the items that are required will depend upon the type of fumigation operation that is to be implemented.

This objective will identify the types and uses of equipment and supplies that are commonly required for fumigating.

Fumigant. As you have already discovered in objective 414, there are many fumigant compounds that are available for use in Air Force pest management programs. The uses of these compounds were also discussed within the same objective. Therefore, they will not be discussed at this time, although you should review these compounds before you continue this objective.

Covering material. For all inplace stack and structural fumigation operations, an air-tight cover is required to be placed over the stack or building to contain the fumigant. A heavy thick material such as a 10 mil polyethylene or canvas cover is required for all fumigation operations except when fumigating with

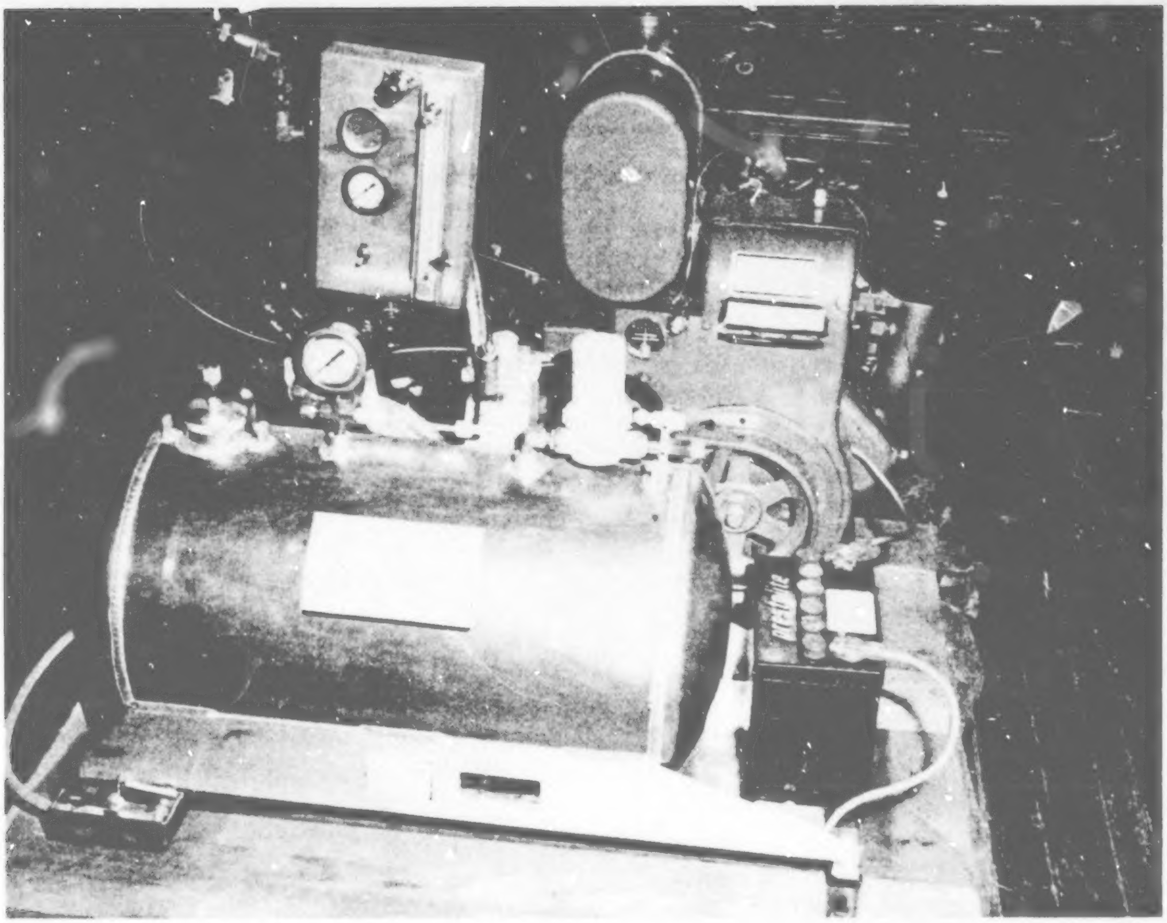


Figure 2-22. Nonportable ULV generator (typical).

hydrogen phosphide. To perform inplace stack fumigation using hydrogen phosphite, a light, thin (2 to 6 mil) polethylene film covering should be used.

Packing material. Any type of material can be used to pad all areas on a stack or building that could create a tear in the covering material.

Tape. Wide masking tape is useful for taping the packing material to corners and other protrusions of stacks and buildings. However, plastic pressure sensitive tape (4 inches wide and 4 mil thickness) should be used to reinforce the portions of the covering that are likely to come in contact with corners or other protrusions should the packing material fall off. The wide cloth or cellophane tape can also be used to make temporary repairs to the covering in the event it becomes torn.

Sand snakes. This term "sand snakes" applies to the tubing that is used to seal the bottom edges of the covering material that is used in inplace stack, structural, and soil fumigation operations to the floor or ground. Sand snakes are prepared by filling tubes (6 feet long and 5 inches wide) that have been formed from 10 mil polyethylene, nylon, or canvas material with sand.

Tape measure. Fumigants must be applied at a certain rate within a specific amount of space; therefore, a tape measure is required to determine the amount of space that is required to be treated before the operation.

Fans. Sparkproof electrically operated fans are required to be used when conducting inplace stack and structural fumigation operations with methyl bromide or carbon disulfide to keep the fumigant circulating. Without the fans, methyl bromide would settle to the floor or ground and carbon disulfide would form pockets at the highest levels in the covering. This would present very hazardous situations in either case.

Fumigant trays. To conduct hydrogen phosphide inplace stack fumigation, the aluminum phosphide pellets and tablets must be loosely scattered in a single layer in an aluminum tray and placed under the stack covering. This prevents the tablets or pellets from coming in contact with foods and materials that could create fire and explosion hazards. Disposal is made much easier by placing the tablets or pellets in a tray, which contains the residue.

Gas detection and metering devices. To perform fumigation operations effectively and safely, gas detection and metering devices are required. Fumigants must be applied at a certain rate per cubic foot of space being treated, which means that there must be so many parts per million of fumigant concentrate contained within the space over a specified period of time. In order for this to be done, you must monitor these concentrates by taking air samples from the area being fumigated with the detection and metering devices as frequently as is specified on the fumigant label. If the concentrate level is higher or lower than the level that is recommended to be maintained, you must make the proper adjustments. Remember, if the concentrate is lower than recommeded, the fumigation operation will not be effective, and if the concentrate is higher, this presents a very potentially hazardous situation.

There are many types of gas detection and metering devices available for use with fumigants; in many cases, there may be several devices for each fumigant. For example, the MSA pump, Drager bellows pump, and the Auer bulb detection apparatus and detection tubes are all available for use with hydrogen phosphide.

These items or other similar items of detection and metering devices are available for use with other types of fumigants and will provide you with the ppm of fumigants contained within a treated area.

> *NOTE: In order to obtain an accurate reading of the amount of fumigant contained in an area, you must have the appropriate detection apparatus for the fumigant being used, and the detection tube must be specifically designed to match the apparatus being used.*

Other devices that are available for use in detecting the presence of gases other than oxygen and carbon dioxide within the air are Halide gas detectors, fumiscopes, and explosimeters. These devices are only designed to detect contaminant and explosive properties within the atomosphere and will not identify the type of fumigant exposed.

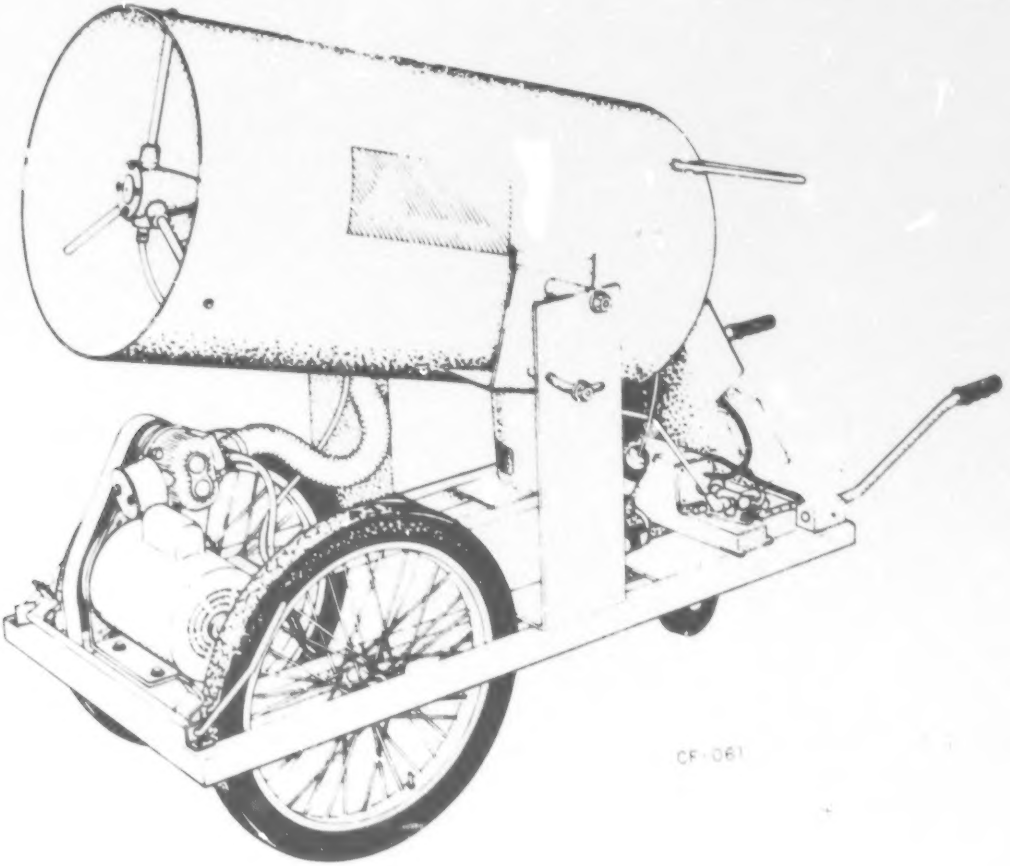


Figure 2-23. ULV generator for warehouse treatment

Vaporization trays. In most methyl bromide fumigation operations conducted within the Air Force, a plastic tube is extended from the nozzle of the fumigant container to a stainless steel tray which allows the liquid to flow from the container into the tray for vaporization.

Thermometers. Atmospheric and commodity temperatures are very important contributing factors in the effectiveness and safeness of most fumigation programs. For instance, methyl bromide can be used effectively in areas where temperatures may be 39° F (4° or possibly lower, whereas hydrogen phosphide is not to be used in areas where the temperature is below 40° F (4.48° C).

In almost all cases each fumigant will have an optimum temperature in which it will be most effective, and the optimum temperature will vary with each fumigant; thus, the gas concentration and time of required exposure will vary as the temperatures vary. It is for this reason that a thermometer is required in fumigation operations.

Moisture permeable envelopes. For railcar fumigation with aluminum phosphide pellets or tablets, special moisture permeable envelopes are required for containing the pellets or tablets.

Warning signs. Regardless of the type of fumigation operation that is to be conducted, warning signs that specify the type of fumigant being used, precautions to be taken, and emergency phone numbers of responsible individuals must be conspicuously posted at every visible approach to the area where fumigation is to occur.

Safety protective equipment. As previously discussed in Volume 2, coveralls, gloves, and a hat must be worn during all phases of fumigant handling and monitoring. An approved full-face respiratory device designed to protect against the fumigant compound must be worn during all phases of handling and monitoring all types of fumigants with exception to paradichloro-benzene, naphthalene, and aluminum phosphide.

A respiratory protective device is not required to be worn while applying aluminum phosphide tablets, pellets, or bags as long as the application can be completed within 20 minutes; however, an approved respiratory protective device and canister must be readily available or within the possession of the operator.

Exercises (433):

1. When performing in-place stack fumigation with hydrogen phosphide, a light, thin ____________ film is used.

2. To prevent tears in the covering materials, projection or sharp edges are padded with ________________.

3. What is the tubing used to seal the bottom edges of covering material called?

4. What is used to determine the amount of space prior to fumigating?

5. To keep the fumigant circulating, sparkproof, electrical ____________ are used.

6. Aluminum phosphide pellets and tablets are loosely scattered in a single layer in an ______________.

7. To perform fumigation operations effectively and safely, gas detection and ______________ devices are required to be used.

8. Methyl bromide is vaporized in a stainless steel ______________.

9. Where are aluminum phosphide pellets or tablets placed when used to fumigate railcars?

10. Warning signs will be conspicuously posted at every visible approach to the area being ______________.

11. An approved ______________ protective device and canister must be readily available when applying fumigants.

434. Match the listed trapping devices with the animals they are primarily used for in trapping.

Trapping Devices. Most of the trapping devices that are used in managing pests were identified and discussed in Volume 2. The trapping devices previously identified are used not only for collecting pests in surveys, but they are also very beneficial and often the most practical for controlling pests in many situations.

Light traps. The types of light traps that are illustrated in figures 2-1 through 2-4 of Volume 2, kill many nocturnal flying insects that would not be killed otherwise. These traps can be used near patio or camping areas to attract mosquitoes and nuisance pests away from the areas that you want to enjoy. There are other types of light traps that are specially designed with an electrical grid used especially for attracting and killing flying insects around outdoor entertainment areas.

Baited jar traps. These traps are very useful for controlling many types of crawling pests. This type of trap is often the safest for use in controlling cockroaches in child care centers where pesticides would be unsafe. These jar traps can also be used to some degree as a personal protective measure by placing the legs of beds in jars to prevent scorpions, centipedes, and millipedes from crawling into bed with you. Jar traps are also effective in attracting certain flying insects such as flies, bees, and wasps.

Cage traps. Cage traps of the types previously identified (figs. 2-7 and 2-8 of Volume 2) are very effective in controlling almost all domestic and field rodents and many types of predatory animals. The larger types of these traps are especially useful for controlling birds and predatory animals that are protected by Federal, state, and/or local laws.

Steel and wood-base snap traps. Steel and wood-base snap traps such as the ones illustrated in figure 2-24 are used for controlling vertebrate animal pests when injury or death to the animal is not of concern. These types of traps are most often used within the Air Force for controlling domestic and field rodents. The small wood-base snap traps are used primarily for controlling mice indoors, although they are sometimes used in the control of field mice outdoors. The larger wood-base snap traps and steel traps are most often used to control rats indoors and outdoors and to control field rodents and other pest mammals. Steel and wood-base snap traps may be used baited or unbaited, depending upon where they are to be used and for what they are to be used.

Exercises (434):

Match the use of traps in column A with the trapping devices in column B.

Column A
Use

____ 1. Used to control most domestic and field rodents.
____ 2. Used to control vertebrate animal pests when injury or death to the animal is not of concern.
____ 3. Used to kill nocturnal flying insects.
____ 4. Used to control cockroaches where it is unsafe to use insecticides.

Column B
Trapping Devices

a. Light traps.
b. Bait jar traps.
c. Cage traps.
d. Steel and wood-base snap traps.

435. Specify the uses and effectiveness of miscellaneous pest management equipment.

Types and Uses of Miscellaneous Pest Management Equipment. There are several miscellaneous items of equipment that are used in managing pests. Miscellaneous items of equipment as discussed in this objective refer to devices that are not normally considered to be items used by pest managers.

Because you may be required to use miscellaneous items of equipment yourself or you may require their use by someone else, you must be knowledgeable of these items and their uses.

Frightening devices. These devices are principally used in the control of birds without causing harm to them. There have been many devices designed and tested for controlling birds, but the ones that have proven most effective are *carbide exploders, revolving flashers,* and *sound recordings.*

Revolving flashers are normally installed in rafter areas inside aircraft hangers, vehicle maintenance facilities, and warehouses and are operated intermittently during the night.

Carbide exploders of the type illustrated in figure 2-25 and sound recordings of birds in danger can be used in areas along flight lines to keep birds off aircraft runways and taxiways to prevent damage to aircraft.

Regardless of the type of mechanical frightening device employed in managing pest birds, they must be operated infrequently to prevent the birds from becoming accustomed to the device.

Shotguns fired into the vicinity of bird flocks have been proven most effective of all frightening devices in the control of birds in open areas along flight lines, and discharging pellet rifles in hangars, warehouses, and maintenance facilities have been effective in keeping birds out of these places.

> *NOTE: The use of firearms as frightening devices on Air Force bases must be approved by the base commander and is normally accomplished by security police personnel.*

Tranquilizing devices. These devices are generally gas-operated dart guns and are used in controlling many types of wild animals such as skunks, raccoons, coyotes, and foxes that strayed or became established on Air Force installations. These devices are also used to control stray domestic animals such as dogs and cats that are allowed to run loose on base. The operation of tranquilizing devices is the responsibility of security police personnel and requires special training because the amount of tranquilizer to be used is determined by the weight of the animal to be tranquilized and using the correct amount is very critical.

Other application devices. Aerial dispersal is the distribution of pesticides from aircraft. It is done according to an established plan to obtain maximum efficiency in pest control. The establishment of the need for aerial spraying involves a knowledge of the pest species. To obtain uniform coverage of an area, preplanned flight patterns, altitudes, and airspeeds

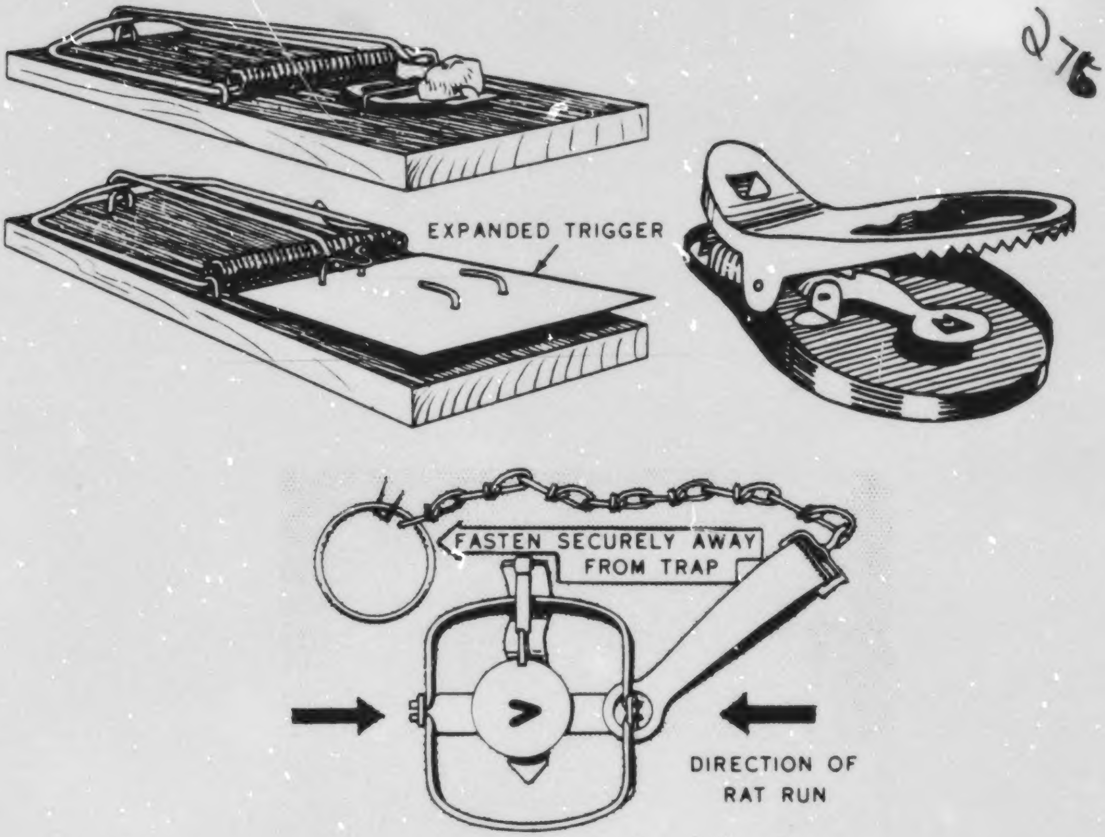


Figure 2-24. Steel and wood base snap traps.

must be carefully followed. To operate at excessive altitudes or in high winds will cause dissipation of the pesticide, resulting in insufficient chemical pesticide reaching the control area.

Air Force Regulation 91-22 describes the procedures for pest control by aircraft. Aerial spraying conducted within the Air Force is accomplished by the aerial spray flight located at Rickenbacher Air Force Base, Columbus, Ohio. The aerial spray flight is operated by the Air Force Reserves. Requests for aerial spraying must be justified; therefore, this type of control must be discouraged unless there is an urgent need for it. All aerial spray operations are carried out under the direction of specially trained personnel who accompany the aircraft. Local responsibility, once the initial request is made, is usually limited to assisting the spray personnel upon their request.

Early morning or just before dusk is the most effective time to do aerial spraying. Aerial spraying is expensive; therefore, before a spraying program is planned, costs of modification and operation of necessary aircraft should be weighed against the cost of ground control units. Also, effective aerial spraying can be accomplished only by flying at low altitudes, and certain terrain or major obstructions may limit spraying operations. Any major deviation from standard spraying procedures to avoid obstructions will nullify the benefits of aerial spraying.

Another point to consider during the planning stages of aerial spraying is the probability of endangering wildlife. Normally, birds and mammals are not affected by insecticides deposited at a normal rate, but they may be endangered if higher-than-normal rates are used.

Aerial dispersal of pesticides permits a quick coverage of large areas. When time is of the utmost importance to prevent massive infestation or an outbreak of disease, aerial spraying is the only practical measure of effective control. Aerial spraying also permits coverage of terrain inaccessible to ground equipment.

Pouring of chemicals may be of value under certain conditions. Measured amounts of insecticide may be poured into fast-flowing streams for blackfly control. A sprinkler can be useful for mosquito larviciding of catch basins.

Dragging bags of chemicals through water, or laying the bags in moving water may serve to control blackfly larvae or other water-dwelling forms. Calculations should be made to assure adequate control without damage to fish or other wildlife. Do not pollute human water supplies.

Drip cans are superior to pouring or dragging for water treatment because pesticide dosage can be controlled more exactly. They are better suited to use in moving than in still water.

Paint brushes are very effective for applying controlled amounts of pesticides to areas where pests hide or run. They are especially suited for controlling household insects such as cockroaches and silverfish. There is less chance of damaging materials such as synthetic floor tiles or painted woodwork when applying pesticides with a paint brush than with a sprayer.

Exercises (435):

1. Name the frightening devices that have proven most effective.

2. The use of firearms as frightening devices on Air Force installations must be approved by the ____________________.

3. Aerial dispersal of pesticides permits a ________ coverage of large areas.

4. Tranquilizing devices are generally gas-operated __________ guns and are used to control many types of wild animals.

5. Measured amounts of insecticide may be __________ into fast-flowing streams for blackfly control.

6. Blackfly larvae may be controlled by __________ bags of chemicals through water or __________ the bags in moving water.

7. What is an effective method of applying measured dosages of pesticides for water treatment?

8. An effective method of applying controlled amounts of pesticides to areas where pests hide or run is by using ____________ .

436. Identify the types of pesticidal pumps with their selection, use, and care.

Types and Uses of Pesticidal Pumps. There are several types of pumps that are available for applying pesticides, and each type has its own characteristics. When ordering equipment, you must also specify the type of pump desired, because in most cases, an item of equipment can be equipped with several types of pumps. Therefore, if the type of pump desired is not specified, you are apt to receive an item of equipment that you cannot use or one that you will have very little use for.

When selecting pumps, you must consider the type of pesticide and pesticide formulation that is to be used most often in the pump and how much pressure and volume is going to be required for dispersing the pesticide formulation.

The pump selected must be adequate for all spraying pressures you are going to use, and it must provide enough flow to:

- Supply all nozzles.
- Allow for hydraulic agitation when needed.
- Leave a reserve to allow for loss of flow due to wear.

Pumps should resist corrosion and abrasion. The capacity of the pump should be about twice the nozzle delivery rate to provide for an overflow that is bypassed back to the tank for agitation of the spray. The several types are as follows:

(1) A rubber-impeller pump is cheap, is not injured by abrasive suspension, develops about 35 psi, but is not adapted for oils.

(2) A rotary-gear pump has positive action. The discharge rate depends on the speed of rotations. Suspensions are hard on the gears. It is cheaper to replace plastic gear pumps than to repair permanent equipment.

(3) A centrifugal pump is a single-rotating impeller type. It pumps a large volume of spray but does not develop a high pressure—40 to 70 psi. It can handle all spray materials with minimum wear. It is not self-priming, so must be mounted lower than the tank. Unlike most pumps, it pushes the liquid in one direction only.

(4) A piston pump is designed for large quantities of spray and moderate to high pressures—up to 1,000 psi. It has one or more plungers connected to a crankshaft. The plungers or pistons can be used for any type of sprayer, stand rough treatment, and are long lasting but expensive.

(5) A nylon-roller pump gives good service, but it is expensive and is not well adapted for suspensions. It pumps only after reaching a high speed.

(6) A diaphragm pump is similar to a piston pump except that one side of the chamber is made of a flexible fabric that creates the vacuum. This pump handles abrasives well, but the fabric does not always last long under the pressure normally required for spraying. The diaphragm, however, can be replaced easily and economically.

Remember, centrifugal pumps provide high volume at low pressure. They are not self-priming. Piston and

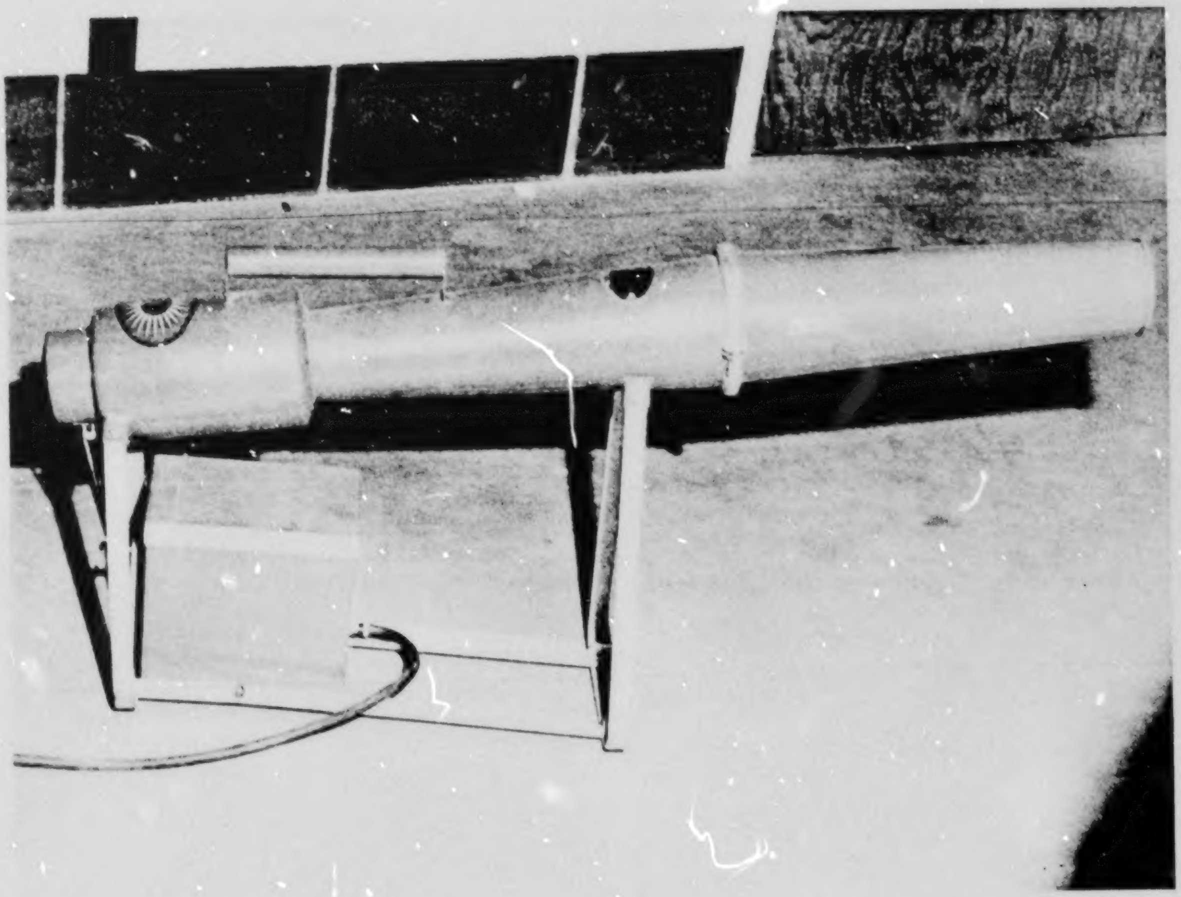


Figure 2-25. Carbide exploder (typical).

disphragm pumps provide moderate to high volumes at high pressure. They are self-priming. Roller and gear pumps provide moderate volume at low to moderate pressure. They are self-priming in most equipment. Do not use wettable powder formulations in gear pumps. If you need pressures about 75 psi, piston pumps are more likely to provide them over a long period of time.

You will damage a pump if you operate it dry or with a restricted inlet. Follow the manufacturer's recommendations for pump operation. Keep all shields in place.

Exercises (436):

1. Match the pump types in column B with statements in column A by placing the number, representing a type of pump, in the blank provided by the appropriate statement; some statements may apply to more than one pump.

Column A	*Column B*
____ a. Do not use with wettable powder formulations.	1. Centrifugal.
____ b. Not self-priming.	2. Piston.
____ c. Used for pressures over 75 psi.	3. Diaphragm.
____ d. Self-priming.	4. Roller or gear.
____ e. Provide high volume at low pressure.	
____ f. Provide moderate volume at low to moderate pressure.	
____ g. Provide moderate to high volumes at high pressure.	

2. Complete the following statements concerning pesticide pumps:

a. When ordering equipment you must specify the ________________ desired.

b. When selecting pumps, you must consider the type of pesticide and ________________ .

c. The pump selected must be adequate for all spraying ________________ you are going to use.

d. Pumps should resist ________________ and ________________ .

e. You will damage a pump if you operate it ________________ or with a ________________ inlet.

437. Match the type of spray pattern produced by nozzles and their uses with the appropriate type of nozzle described.

Types and Uses of Nozzles. The nozzle is the most important part of the sprayer, for it determines how the pesticide will be sprayed—as a solid stream, flat fan, hollow cone, solid cone, or broadcast. It also determines the rate of spray output at a given pressure. Nozzles are available in many types and styles, each designed with a particular purpose in mind. They may be mounted in many ways. If two or more nozzles are placed at the end of a wand, the spray gun is referred to as a spray boom. The orchard spray gun has a single nozzle that can be adjusted to produce spray patterns varying from a solid stream to a fine mist by reducing the size of the whorl chamber. Many commercial compressed air sprayers have adjustable nozzles. However, nonadjustable nozzles are desirable for Air Force pest management programs, because they may be depended upon to deliver a definite amount of pesticide per unit of time.

The pesticide distribution rate and pattern of nozzles is dependent upon:

- The nozzle design or type.
- Its operating pressure.
- The size of the opening.
- Its discharge angle.
- Its distance from the target.

Solid stream nozzle. This type of nozzle applies a fine stream of pesticide and is used in spray guns to spray a distant target and for crack and crevice treatment in buildings. The solid stream nozzle is also used in a nozzle body to apply pesticides in a narrow band or inject them into the soil.

Flat fan nozzles. There are three types of flat fan nozzles:

(1) The *regular* flat fan nozzle makes a narrow oval pattern with lighter edges. It is used for broadcast spraying. This pattern is designed to be used on a boom and to be overlapped 30 to 50 percent for even distribution.

(2) The *even* flat nozzle makes a uniform pattern across its width. It is used for band spraying and for treating walls and other surfaces.

(3) The *flooding* nozzle makes a wide-angle flat spray pattern. It works at lower pressures than the other flat fan nozzles. Its pattern is fairly uniform across its width. It is used for broadcast spraying.

Hollow cone nozzle. There are two types of hollow cone nozzles: the core and disk, and the whirl chamber.

The pattern is circular with tapered edges and little or no spray in the center. It is used for spraying foliage and mosquito larviciding.

Solid cone nozzle. This nozzle produces a circular pattern with the spray being well distributed throughout the pattern and is used for spraying foliage and mosquito larviciding.

Broadcast nozzle. This nozzle forms a wide flat fan pattern and is used on boomless sprayers and on boom sprayers when attached to the end of the boom to extend the effective swath width.

Exercises (437):

Match the type of nozzle in column A with its spray pattern and use in column B by placing the correct letter in the blank space provided.

Column A

____ 1. Solid stream nozzle.
____ 2. Flat fan nozzle (regular).
____ 3. Hollow cone nozzle.
____ 4. Solid cone nozzle.
____ 5. Broadcast nozzle.

Column B

a. Circular pattern with the spray well distributed throughout the pattern.
b. Designed to be used on a boom and to be overlapped from 30 to 50 percent.
c. Forms a wide, flat, fan pattern and is used on boomless sprayers.
d. Used to spray distant targets and cracks and crevices in buildings.
e. The pattern is circular with tapered edges and with little or no spray in the center.

438. Match typical numbers that may appear on nozzles with their appropriate meaning.

Interpreting Information Contained on Nozzles. Most nozzles supplied with compressed air sprayers have a *nozzle disc* consisting of a simple steel plate with a hole in the center instead of the more elaborate nozzle tip. These discs often have numbers stamped on them ranging from 1 to 10, representing 64ths of an inch. Thus, a No. 7 disc would have an aperture of

7/64-inch in diameter, and would produce larger droplets suitable for heavy applications. A number 1 disc would produce a very fine spray. Disc nozzles are commonly used for large power sprayers that operate at high pressures, producing a very fine mist. They are also satisfactory for applying pesticide suspensions with the compressed air sprayers.

Several manufacturers have developed nozzle systems in which carefully calibrated nozzles are designated by number.

Teejet nozzles are rated according to the angle at which the spray leaves the nozzle and to the output in tenths of a gallon per minute at a pressure of 40 psi (Pounds per Square Inch). Thus, an 8002 nozzle used in residual spraying of emulsions on ordinary surfaces produces a flat fan spray at an 80° angle with a rate of 0.2 gallon per minute at a pressure of 40 pounds per square inch. Similarly, a 5004 nozzle used in residual spraying of suspensions on porous surfaces produces a flat fan spray with a 50° angle with a rate of 0.4 gallon per minute at a pressure of 40 psi; and a 0001 nozzle used to apply emulsions or solutions to cracks and crevices for cockroach control produces a solid stream at 0.1 gallon per minute with a pressure of 40 psi. Many pest control operators in buildings wish to change the spray pattern from time to time as they work through a building. Therefore, they use a Multeejet nozzle with 4 openings, two (50015 and 730039) to produce fan type sprays, and 2 (000021 and 0001) to produce solid stream sprays.

Exercises (438):

Match the given nozzle number in column A with the statement number in column B that correctly identifies it by placing the letter in the space provided.

Column A	*Column B*
____ 1. 0001.	a. Produces a flat fan spray at an 80° angle with a rate of 0.2 gallon per minute.
____ 2. 6.	b. 6/64.
____ 3. 5004.	c. Applies emulsions and solutions to cracks for cockroach control.
____ 4. 8002.	d. Produces a flat fan spray at a 50° angle with a rate of 0.4 gallon per minute.

2-2. Equipment Operation.

Operating equipment properly is just as important in the safe and effective application of pesticides as is selecting the right equipment for the formulation and type of treatment. You can have the right equipment for the formulation to be dispersed and the type of treatment to be implemented; but, the pest management program can still be ineffective and unsafe if you operate the equipment improperly.

Another aspect that must be considered in operating equipment is the fact that equipment must be operated properly to prevent damage to the equipment. If equipment is operated improperly, it is most certain that damge will occur, sooner or later, and the efficiency and safety of the equipment will be reduced.

This section provides information that will assist you in operating pest management equipment properly and safely. This information will consist of identifying the types and uses of operational and maintenance guidelines and outlining operational procedures and safety precautions.

439. List the types of operational guides and identify the statements pertaining to operational and maintenance guides as being true or false.

Operational and Maintenance Guides. Proper operation and maintenance of equipment can best be accomplished by using the commercial or Government publications that outline operational, maintenance, and safety procedures for a specific item of equipment. As a matter of fact, you are required to follow the operational, maintenance, and safety procedures that are outlined in these publications, provided there is a publication written for the item of equipment you are to use.

These publications may be identified as technical orders (TOs) for the Air Force, technical manuals (TMs) for the Army and Marine Corps, NAV DOCS (MOs) for the Navy, technical information memorandums (TIMs), and commercial manuals for all Services.

In many cases, one publication for an item of equipment will be used jointly by two or more services. When this occurs, the publication will reflect a TO number, a TM number, and/or an MO number that has been assigned by the appropriate services involved. Other publications that are used jointly by the services may reflect a TIM number which would apply to all services.

Commercial publications, such as the Operation Manuals, may or may not be assigned a TO, TM, or MO number by the appropriate services. If there is an item of equipment which is manufactured by the same company that is purchased and utilized by a majority of Air Force, Army, Navy, and/or Marine Corps installations, the commercial publication will probably be assigned a TO, TM, and/or MO number.

There are other types of publications that may be available for you to use when operating or maintaining equipment. These publications may be in the form of standard operating procedures (SOPs) or operational instructions (OIs) and generally prepared by the organization to which you are assigned.

Regardless of the type of publication that is available for operating and maintaining equipment, the publication must be adhered to and regarded in the same manner as though it were an Air Force regulation.

For items of equipment that have any of these types of publications, the equipment must not be operated or maintained unless the publication is being used by the operator or mechanic during the actual operation or maintenance.

Exercises (439):

1. List seven types of technical publications that may be used for the correct operation, maintenance, and safety of pesticide equipment.

2. Answer the following statements as true or false:

____ a. Technical orders (TOs) are used primarily by the Air Force.
____ b. Commercial publications are used by the Navy and Marine Corp.
____ c. Technical manuals (TMs) are used by the Army and Marine Corp.
____ d. Technical information memorandums (TIMs) are used by all the services.
____ e. Standard operating procedures (SOPs) and operational instructions (OIs) are generally prepared by the using organization.

440. State the purpose and frequency of conducting preoperational inspections.

Preoperational Inspections. Before operating any item of equipment, you must perform a preoperational inspection on the equipment. Preoperational inspections must be done prior to each use, regardless of how soon since the equipment was last used. If there is a publication that outlines the preoperational procedures for the item of equipment to be operated, it must be used during the preoperational inspection.

Preoperational inspections on equipment are performed to insure that the equipment can be safely operated at its optimum efficiency. These inspections must be accomplished on each item of equipment, regardless of the type, whether it is a mouse trap or the Government vehicle that you drive, and even if there are no written guides pertaining to the equipment.

Besides being required, preoperational inspections are performed to reflect a true professional pest manager, because the manger is only as good as the equipment. It can be very embarrassing for you and the section when you have filled compressed air sprayer, ready at the job site to apply the pesticide; and, the sprayer doesn't operate or it leaks profusely from the pump handle, simply because you neglected to perform the preoperational inspection on the equipment.

Exercises (440):

1. What is the purpose of conducting a preoperational inspection?

2. How often should preoperational inspections be performed?

3. What must you do before operating any piece of equipment?

4. What are preoperational inspections on equipment designed to insure?

5. Besides being required, preoperational inspections are performed for what reason?

441. Match given types of manual spray equipment with preoperational inspections and operational procedures.

Operation of Manual Sprayers. As previously stated, before operating any item of equipment, a preoperational inspection of the equipment is required. Therefore, you must be knowledgeable of sprayer components and inspection procedures.

In order to obtain optimum operational efficiency of spray equipment, or any other equipment, it must be properly prepared for operation, and then, it must be operated in accordance with the appropriate operational guide. Because there are normally several variations for each type of spray equipment, discussion within this objective concerning preoperational and operational procedures for equipment must be restricted to generally common procedures. We will also identify safety precautions that must be taken while handling the equipment.

Compressed air sprayers. The compressed air sprayer has a small 1- to 3-gallon cylindrical tank equipped with an air pump, hose, spray gun, and other components necessary for applying liquid insecticides. An exploded view (with identified components) of a typical compressed air sprayer is illustrated in figure 2-26. The tank should be filled two-thirds to three-fourths full and air compressed into the remaining space. This compressed air exerts pressure on the liquid and forces it through the outlet pipe, hose, cutoff valve, and nozzle. As the liquid leaves the nozzle, the spray pattern will depend on the air pressure maintained in the sprayer and the type of nozzle used. The air should be compressed to 40 psi, after which spraying may continue until pressure drops to approximately 30 psi.

To assist you in performing a preoperational inspection on the compressed air sprayer, typical procedures are provided. Refer to figures 2-26, 2-27, and 2-28.

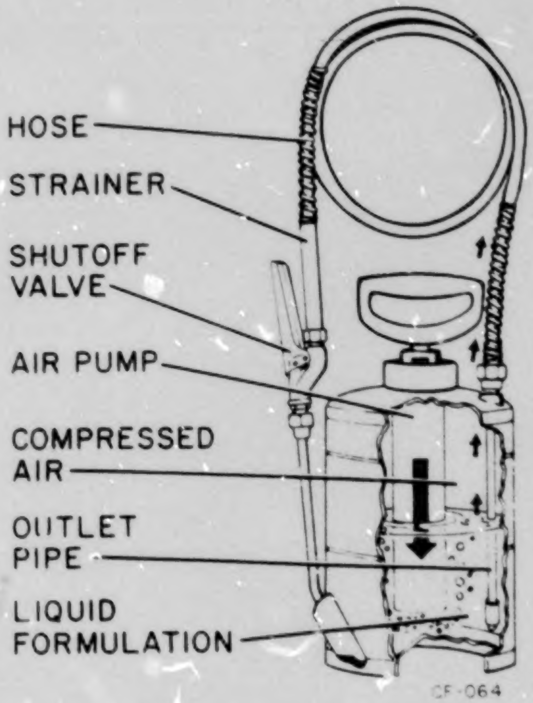


Figure 2-26. Typical compressed air sprayer (exploded view).

a. If the sprayer is unopened, turn the pump assembly counterclockwise very slowly to insure that all pressure has been relieved from within the formulation tank. When the pump assembly is opened faster than the air is allowed to escape, it is very damaging to the threading at the top of the tank and within the pump assembly; plus, it can cause serious injury to the operator because the pump assembly could be ejected upward by the pressure within the tank.

b. Check the threading on the tank and within the pump assembly to insure the threads have not been worn away or broken off.

c. Insure that the pressure release opening is clear to allow the release of pressure when pump assembly is turned counterclockwise. This pressure release opening is located on the exterior top portion of the pump assembly.

d. Insure the pump assembly rod is straight to prevent excess wear to the pump assembly bonnet.

e. Insure that the gasket is in place, is straight, and is not brittle or deteriorated.

f. Check the pump cylinder to insure that it is not dented and is not cracked. The inner portion should be cleaned frequently with a large bottle brush to prevent caking of formulations and to remove corrosive substances that may cause pitting.

g. The check valve must be inspected to insure that it is in place, is not deteriorated, and is not lodged open by debris and metal filings. The area between the check valve and the pump cylinder should be flushed with water frequently to remove debris and metal filings.

h. Inspect the piston cup to insure that it is firm, but pliable. The cup should be lubricated periodically with vegetable oil to prevent it from becoming dry.

i. Check the outlet pipe to insure that it is securely attached and is free of debris.

j. Check the formulation tank for cracks and holes that may be in the tank or around solder joints.

k. Insure that all hose and wand fittings and couplings are tight.

l. Inspect the hose to insure that it has not become brittle and to insure there are no cracks or holes.

m. Insure that the cutoff valve is functioning properly.

n. The spray gun assembly should be inspected periodically to insure that strainers are unclogged and to insure that O-rings and seats are in good condition and are free from debris.

Once the sprayer components have been inspected, pour plain water into the tank, insert the pump assembly and secure it, pressurize the tank, and inspect for leaks and tests the shutoff valve. If there are no leaks and the shutoff valve functions properly, the sprayer is ready for use.

Always insure that the pressure is released after each use and never transport the sprayer with pressure applied. Pesticide formulations should not remain in the sprayer for an extended period of time.

Aerosol dispensers. The small, low-pressure aerosol dispenser consists of a can with a discharge valve and nozzle at the top, and a tube extending from the valve to the bottom of the can. The insecticide is a concentrated oil solution is mixed with a propellant (usually the nontoxic gas Freon in liquid form) and placed in the can at the time it is assembled. When the discharge valve is pressed, propellant gas within the can forces the insecticide-propellant mixture through the nozzle and it is atomized into spray.

The large, high pressure aerosol dispenser has a much heavier constructed tank, extended nozzle, and a shutoff valve that is turned to regulate the rate of discharge.

A preoperational inspection on this item of equipment consists of checking the container, valve, and nozzle to insure that these items are not corroded or damaged.

Always store aerosol dispensers in a cool place and never throw used ones into a fire.

Siphon atomizers. With the intermittent type of siphon atomizer, a piston pump forces a stream of air over the tip of the siphon tube. This creates a partial vacuum in the tube. The insecticide is sucked from the tank attached to the pump into the airstream which breaks the insecticide into spray. The principle of

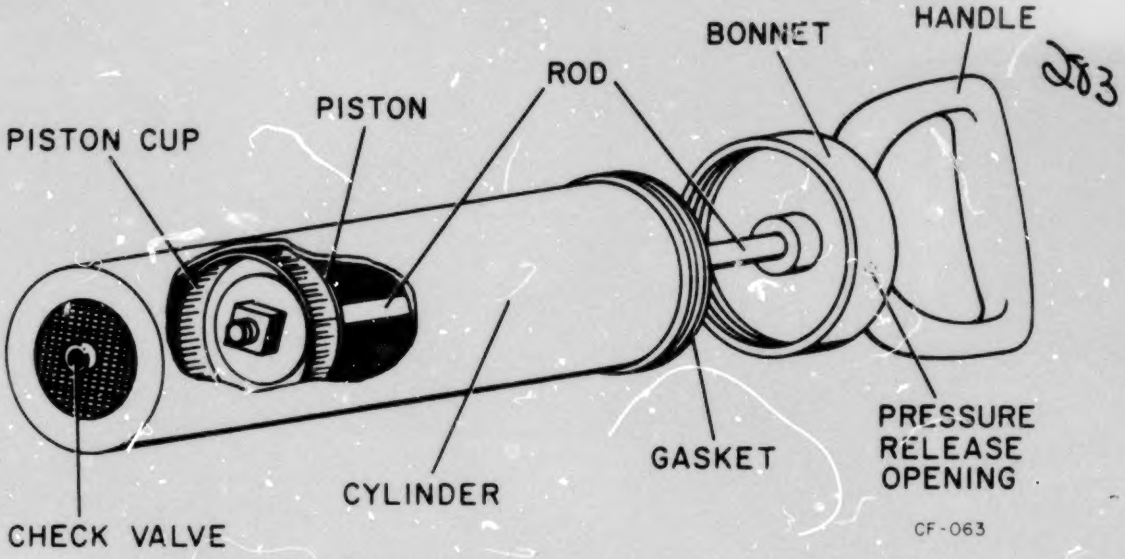


Figure 2-27. Pump assembly (exploded view).

operation for this atomizer may be better understood by viewing figure 2-29 which provides an exploded view with identified components of the intermittent siphon atomizer.

The continuous siphon atomizer forces air into the tank to develop and maintain a constant pressure and deliver a continuous spray discharge.

To perform a preoperational inspection on this item of equipment, follow these procedures:

- Check the formulation tank and pump cylinder for deterioration.
- Insure that the gasket beneath the filler cap is in position and is not deteriorated.
- Insure that the plunger cup is firm but pliable.
- Insure that the nozzle and siphon tube are not damaged and are free of debris.

Piston sprayers. A fine, solid stream of insecticide is produced by pulling the trigger on the gun. Piston sprayers are especially designed to resist corrosive chemicals.

A preoperational inspection on this item of equipment includes checking the container for cracks and holes and insuring that the closure gasket is in place and is in good condition. The trigger assembly should also be tested to insure that it is operable, and the nozzle must be free of debris.

Knapsack sprayers. A simple diaphragm or piston pump and a mechanical agitator are mounted inside the tank and actuated by a lever worked by the operator's right hand. The pesticide is under liquid pressure during each stroke of the pump. The operation may be better understood by viewing figure 2-30, which provides an exploded view of a knapsack sprayer and identifies the components that were discussed.

To perform a preoperational inspection on the knapsack sprayer you would check the tank, spray gun, and hose in the same manner and for the same purpose as you would the compressed air sprayer. In addition to these items, you should check the operating lever to insure that it is operable, check the

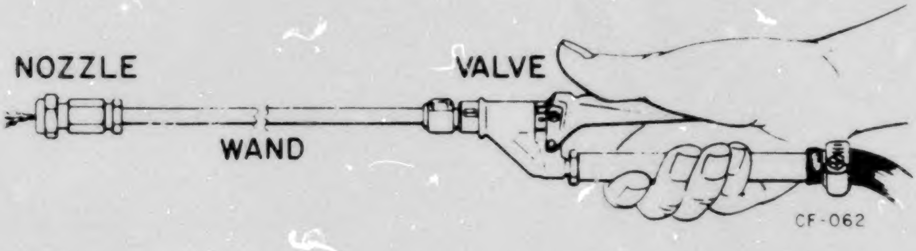


Figure 2-28. Spray gun assembly.

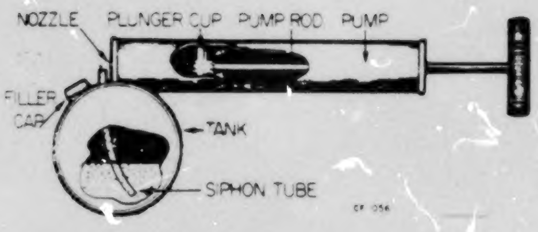


Figure 2-29. Typical siphon atomizer (exploded view).

agitator to insure that it is secure and operable, and insure that the diaphragm is in place and has not become deteriorated.

Trombone sprayers. This item of equipment is operated by holding onto the rear handle with one hand and pushing and pulling the front handle in a trombone-like action. This action causes a plunger and a cylinder to move on each other, creating a siphoning action.

A preoperational inspection on this equipment includes checking the spray gun to insure that it is operable and insuring that the hose is in good condition and the nozzle is free of debris.

Garden hose sprayers. This sprayer is designed to connect to a garden hose and utilize the household water supply and water pressure for dispersing the pesticide. It consists of a jar for holding concentrated spray material, a spray gun attached to the lid, and a suction tube from the gun to the bottom of the jar. A shutoff valve is provided at the gun. The gun draws the spray concentrate from the jar by suction through tubes and mixes it with the water flowing from the garden hose through the gun. This makes a dilute spray which is delivered from the nozzle.

To perform a preoperational inspection on this item of equipment, you should insure that the hose connecting gasket is in place and serviceable; insure that the hose connection is tight; insure that the shutoff valve is operable; insure that the suction tube is in place and does not contain cracks or holes; and insure that the nozzle is free of debris

Remember the final step in performing preoperational inspections on items of spray equipment is to test them with plain water before filling them with pesticide formulations.

Exercises (441):

Match the type of sprayer with the correct preoperational inspections or operational procedures. The type of sprayer may have more than one statement that applies.

Item of Equipment

____ 1. Compressed air sprayers.
____ 2. Aerosol dispensers.
____ 3. Siphon atomizers.
____ 4. Pistol sprayers.
____ 5. Knapsack sprayers.
____ 6. Trombone sprayers.
____ 7. Garden hose sprayers.

Statement

a. Must be inspected to insure that the diaphragm is in place and has not become deteriorated.
b. Must be inspected to insure that the suction tube is in place and does not contain cracks or holes.
c. Should be operated with a pressure of 40 psi.
d. Is operated by holding onto the rear handle with one hand and pushing and pulling the front handle with the other.
e. A fine, solid stream of insecticide is produced by the squeezing of a trigger device.
f. Pesticide is dispensed by pressing down on the discharge valve.
g. The principle of operation includes a piston pump forcing a stream of air over the tip of the siphon tube which creates a partial vacuum in the tube and sucks insecticide from the tank into an airstream.
h. Required an inspection of the agitator to insure that it is secure and operable.
i. Checking the container, valve, and nozzle is the only requirement for conducting a preoperational inspection on this item of equipment.
j. This item of equipment requires an inspection of the check valve to insure that it is in place, is not deteriorated, and is not lodged open by debris and metal filings.

442. Specify preoperational inspections and operational procedures for manual dusters.

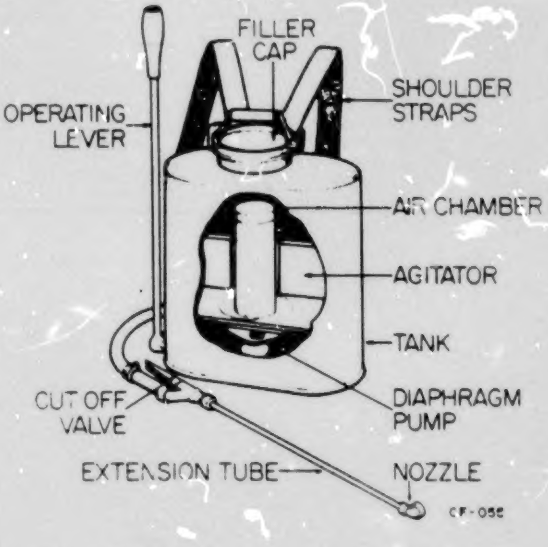


Figure 2-30. Typical knapsack sprayer (exploded view).

Operation of Manual Dusters. Proper operation of manual dusters requires a knowledge of preoperational and operational procedures; therefore, this objective is devoted to identifying these procedures and the applicable safety precautions.

Hand shakers. This shaker is rectangular with a handle attached to one side. The detachable lid has a screen end to sift the insecticide dust when the duster is shaken. A long handle may be attached to the duster to facilitate the treatment of overhead beams and rafters. If the shaker is fitted with 16- to 20-mesh screen, or a perforated lid, a baffle is not necessary to keep the dust from being dispensed in too great guantities.

Be careful when applying dust to high areas to prevent the dumping of dust on yourself. To prevent electrical shorts and possibly fires, do not use this shaker in areas that contain electrical wiring.

Hand bellows. This is a rubber cylinder (about 3" tall) with a metal top and bottom. The top is open and fitted with a cork. The bottom has a metal extension tube. A large coil spring touching the top and bottom supports the device inside. Dust is placed inside the cylinder from the top, the cork is inserted, and dust is blown out through the extension tube by hand pressure on the top and bottom.

A preoperational inspection involves nothing more than checking the rubber cylinder for cracking and splitting and insuring that the spring has appropriate tension and the extension tube is not clogged.

Bulb dusters. The bulb duster is normally a 4-inch rubber bulb fitted with a screw-cap containing a dust nozzle. After the bulb is filled with dust and the cap replaced, hand pressure on the bulb disperses the dust.

Before operating the bulb duster insure that the bulb is not cracked and the nozzle is fitted tightly and is not clogged.

Hand plunger dusters. This item of equipment consists of an air pump with a glass or metal reservoir into which the air blast is directed to disperse the insecticide as a fine cloud or as a more or less solid blast. If the duster is turned so the delivery tube is beneath the dust, very heavy dust patterns will be produced.

A preoperational inspection of this equipment consists of checking the pump assembly in the same manner as for the siphon atomizer pump assembly.

Rotary hand dusters. This duster has a 5- to 10-pound capacity hopper from which dust is fed by a mechanism into a fan case. When the crank is turned, the fan blows the dust through a long tube. Most dusters may be adjusted to deliver from 5 to 20 pounds of dust per acre under normal conditions.

To perform a preoperational inspection on a rotary hand duster check the crank to insure that it is operable and insure that straps are not frayed to the extent of possible breakage.

When operating this equipment outdoors, keep the wind to your back and let the dust blow downwind from you.

Foot pump dusters. The foot pump duster is a hand-operated plunger type blower with a container for rodenticide dust or fumigant. a stirrup is provided so that the pump can be held down with one foot while the operator pumps air and rodenticide into the treatment area through a short length of hose. The 1- and 5-pound capacity foot pumps are most commonly used for fumigating rodent burrows.

A preoperational inspection for this item of equipment includes checking the pump assembly in the same manner as for the hand plunger duster and the siphon atomizer and insuring that the air-selector valve is operable. Check the hose to make sure it is not cracked and is tightly secured to the duster frame.

Operators should wear a gas mask, long-sleeved shirt, and rubber gloves when using calcium cyanide in a foot gun. They should always stand upwind from the point where the hose is inserted into the burrow to avoid inhalation of dust or cyanide gas.

Granular spreaders. The type of granular spreader illustrated in figure 2-13 consists of a rotary slinger plate operated by gears and a hand crank, and a cylindrical metal hopper or cloth bag granule holder. There is a possibility when this equipment is being used in tall grass and cat tails that the gears and rotating plate get clogged with vegetation, which then causes breakdowns. A protective sheet of metal can be mounted parallel to and below the slinger plate and ahead of the [illegible]tter to divert the vegetation away from the moving parts.

Before operating this equipment make sure there are no obstacles that would prevent the rotating plate from turning, insure that the crank handle is securely attached, and inspect the grease fitting for dryness or excessive grease.

Operate this equipment with the wind to your back, making one complete revolution of the crank handle per normal walking step taken, and wear goggles and a respirator.

Exercises (442):

1. Why are hand shakers equipped with a long handle?

2. What does the preoperational inspection of a hand bellows consists of?

3. Before operating the bulb duster, what should you do?

4. The preoperational inspection of the hand plunger duster is the same as which other assembly?

5. What should you do when operating the rotary hand duster outdoors?

6. What is a foot pump duster often used for?

7. When operating the granular spreader, you should make one complete revolution of the crank for each ______________________________ .

443. Match given statements one the operation of portable powered equipment with the appropriate item of equipment.

Operation of Portable Powered Equipment. Although the proper operation of portable powered equipment is no more important than that of the other types of equipment, it is more essential in reducing hazards to the operator and in maintenance expenditures.

Backpack mist-dust blowers. As the name implies, this unit is carried on the back of an operator. These blowers have a tank capacity of 2 to 4 gallons and are powered by a small air-cooled gasoline engine. Some of these machines can disperse liquids, dusts, or granules. They are extremely useful in dispersing adulticides or larvicides over terrain where wheeled vehicles cannot travel. In general, the effective swath is reported as 30 to 80 feet with back-mounted mist blowers.

In performing a preoperational inspection on this equipment, the following items should be checked:

- Formulation tank and return line for cracks.
- Formulation tank cap gasket to insure the gasket is in place and in good condition.
- Harness straps to make sure that they are not frayed to the extent of possible breakage and to insure that all buckles are in tact and operable.
- Dust and liquid formulation dispersal hoses to insure that they are not cracked or do not contain holes and to insure that all couplings are in their proper place and are secure.
- Dust control valve and lever to insure they are operative.
- Liquid control valves to insure they are operative.
- Liquid nozzle to make sure that it is free of debris.
- Turbine blower oil level.
- Fuel level.
- Fuel cap to insure that the gasket is in place and has not become deteriorated.
- Turbine blower filter for cleanliness.
- Air filter for cleanliness.
- Starter pull rope to insure that it is operative and is not frayed to the extent of probable breakage.
- All screws, nuts, and bolts to insure that they are tight.
- Insure that the proper type of gasoline (regular) and oil (nondetergent SAE-30) is used.
- Insure that the proper mixture of gas and oil fuel is obtained and used (1 ounce of oil to 16 ounces of gasoline).

The safety precautions that must be observed when using the backpack mist-dust are as follows:

- Do not operate the equipment beyond the recommended engine rpm.
- Do not overfill the fuel tank or oil reservoir.
- Do not remove the fuel tank cap when the tank is full and the engine is warm.
- Start the engine before placing the equipment on your back to prevent the possibility of gas spilling on you and the engine while trying to start it.
- Keep the equipment as level as possible on your back and avoid excessive shaking to prevent spillage of pesticide and gasoline on you and the engine.
- Operate the engine at low rpms for a short time before turning it off.

Hand-carried thermal fog generators. The type of equipment illustrated in figure 2-15 utilizes a pulse-jet engine similar to that used in the German V-1 buzz bomb during World War II. This equipment has very few moving parts, no rotating parts, and requires no lubrication. Gasoline is burned at the rate of 60 explosions per second, producing hot exhaust gases. An oil solution of insecticide is forced into the tank under 6 psi pressure tapped from the engine head, and the rate of flow is determined by the formulation valve. Particle size may be regulated by adjusting the flow of the insecticide from 0 to 15 gallons per hour, the latter rate depending upon the viscosity of the insecticide liquid. The technique of using this type of fog generator is similar to that used when operating other fog generators. The loud noise produced by the pulse-jet engine is objectionable during the night hours. However, one of the chief advantages of this machine is the fact that the flutter valves cost less than a dollar to replace. An electrical spark and an air pump are used to start it, but are not required after operation has commenced, since the machine is self-igniting after combustion has been initiated.

Preoperational inspection procedures for this item of equipment include checking the following:

- Engine tail pipe to insure that it is not excessively carboned.
- Insecticide injection orifice for cleanliness.
- Fuel tank and insecticide tank to insure that each contains its appropriate substance and does not contain leaks.
- Fuel and insecticide tank caps and gaskets to make sure that they are in good repair.
- Control valves to insure that they are operative and are in the appropriate position for starting.

- Fuel and insecticide lines for cracks and holes.
- Couplings or fittings for tightness.
- Wire guard around the barrel to insure that it is in tact, in place, and is secure.
- Air pump assembly to assure that it is operating properly.

Before attempting to start this equipment, make sure that no one is in front of the barrel or is behind the exhaust, because this item of equipment has been known to shoot fire from both ends. Insure that gasoline is in the gasoline tank and fuel oil is in the insecticide formulation tank because if these substances are reversed it could cause the machine to explode.

While operating the portable thermal fogger, keep it as level as possible, which means that the nozzle must be kept in a horizontal position and not pointed into the air or toward the ground. This equipment must not be operated in confined areas that contain flammable substances.

Handcarried ultra-low volume generators (ULV). Most handcarried ULV generators utilize a small engine similar to the one used with the backpack mist-dust blower. The units will weigh from 15 to 25 pounds and will have a dispersal rate of ½ to 2 ounces per minute.

A preoperational inspection on this item of equipment should include a check of the following items:

- Fuel level.
- Oil level in the supercharger.
- Starter pull-rope for frayed condition.
- Carburetor and supercharger air filters for cleanliness.
- Carburetor sediment bowl for cleanliness.
- Fuel and pesticide tanks for holes and cracks.
- Dispersal hose for crack and holes.
- Nozzle fins for foreign debris.
- Couplings and fittings for tightness.
- Screws, nuts, and bolts for tightness.
- Pesticide tank cap gasket for firmness and pliability.
- Regulating and control valves to insure they are operative.

The hand-carried ULV generator uses a gas and oil fuel mixture. Therefore, you must insure that the proper mixture is obtained and used as prescribed by the operational manual for that particular item of equipment. Generally, the gas and oil fuel mixture will consist of 5 ounces of outboard motor oil to 1 gallon of regular gasoline. This mixture should be prepared in a clean container and mixed thoroughly before putting it into the gas tank.

The engine must be operated at full rpm, and a pressure of 3 to 4 pounds per square inch should be maintained in the air manifold and pesticide tank to be most effective.

Frame-mounted hydraulic sprayers. This item of equipment is generally designed to disperse pesticidal sprays at pressures ranging from 150 to 350 psi at 2 to 4 gallons per minute. It is provided with handles for carrying by 2 people, a suction hose with a strainer for insertion into a separate formulation tank, a return hose, and a discharge hose.

A preoperational inspection on this item of equipment should include a check of the following items:

- Fuel level.
- Fuel tank for cracks and holes.
- Engine oil level.
- Engine cylinder head for foreign debris.
- Pump piston for required oil.
- Unsealed lubrication points for dryness or excessive grease.
- Starter rope for excessive fraying.
- Engine air filter for cleanliness.
- Suction, return, and discharge hoses for cracks and holes.
- Spray gun for operability.
- Nozzles for foreign debris.
- Couplings and fittings for tightness.
- Screws, nuts, and bolts for tightness.
- Drive belt for excessive fraying and proper tension, drive pulleys for tightness and alignment.
- Shut-off and regulating valves to insure they are operative.

Before performing the operational test on this equipment, you should insure that all jewelry is removed and form fitting protective clothing is worn, along with the required safety protective equipment. Make sure that the discharge hose is capable of withstanding pressures in excess of the pressure that is capable of being produced by the pump to prevent hose rupture.

To conduct the operational test, place the suction hose in a sufficient quantity of water, place the pressure regulator control lever in the release position, and close off the discharge hose. Then start the engine and allow it to warm for 2 or 3 minutes. While waiting for the engine to warm, reinspect the equipment for leaks, pulley alignment, and other malfunctions. If no discrepancies are noted, adjust the pressure regulator to the desired operational pressure and open the discharge hose while holding onto it firmly. If all systems are functioning properly, the equipment is ready for use: if not, do not use the equipment until discrepancies have been corrected.

Exploders. The exploder shown in figure 2-25 contains an automatic striking mechanism, a flint, LP-gas regulator with hose, and an LP-gas cylinder. The exploder is operated by the pressure of the LP-gas. As the gas is released through the regulator and hose, it activates the striking mechanism as it passes through to the explosion chamber. Thus, the striker produces a spark from the flint which explodes the gas. The time interval between explosions is controlled by adjusting the precise-regulator. These explosions, which are very loud (approximately 120 decibels), should be no more frequent than every 3 minutes.

To perform a preoperational inspection on this item of equipment, you should check the following:

- LP-gas cylinder for metal weakness and weight.
- Regulator valves and hose for cracks and holes.
- Striking mechanism for foreign debris.
- Flint condition.
- Couplings and fittings for tightness.
- Combustion barrel for foreign debris.

Before performing an operational test on this exploder, you should wear ear plugs or ear protective muffs and insure that the test is not conducted in an open flame area or enclosed area that is occupied by other personnel.

To perform the operational test, connect the regulator valve to the LP-gas cylinder and open the main valve fully. This will activate the striking mechanism and create an explosion if the exploder is operating properly. Set the precise-regulator to the time interval deired and then time the explosion intervals. The amount of time between explosions should be the length of time desired.

Exercises (443):
Match the statements concerning the operation of portable powered equipment in column B with the appropriate item of equipment in column A by placing the correct letter in the blank space provided.

Column A

____ 1. Backpack mist-dust blower.
____ 2. Hand-carried thermal fog generator.
____ 3. Hand-carried ultralow volume generator.
____ 4. Frame-mounted hydraulic sprayer.
____ 5. Exploder.

Column B

a. All jewelry should be removed and form fitting protective clothing worn, along with the required safety protective equipment.
b. The effective swath is between 30 to 80 feet.
c. When performing an operational check, you should wear ear plugs or ear protective muffs.
d. Operates similar to the German V-1 buzz bomb.
e. The gas-oil mixture will consist of 5 ounces of outboard motor oil to 1 gallon of regular gasoline.
f. While operating this item of equipment the nozzle must be kept in a horizontal position and it must not be operated in confined areas that contain flammable substances.
g. This item of equipment must be operated at full rpm and a pressure of 3 to 4 pounds per square inch should be maintained in the manifold and pesticide tank.

444. Cite operational characteristics, inspection requirements, and safety precautions relative to nonportable mist-dust blowers.

Nonportable Mist-Dust Blower Operation. This type of equipment has a four-cylinder gasoline engine, a fan, a hopper to hold pesticide dusts or granules, and a tank to hold liquid pesticides. The high-velocity fan forces air through the large air discharge boom and blows the pesticide dust or granules into the control area, frequently for several hundred feet or yards. The liquid pesticide is forced through special small nozzles into the large air discharge boom and blown from the machine as a spray or mist.

The following items should be checked when performing a preoperational inspection on the nonportable powered mist-dust blower:

- Fuel level.
- Engine oil level.
- Battery water level.
- Battery terminals and cables.
- Gasoline sediment bowl, blower fan, air boom, and nozzles for foreign debris.
- Fuel pump for leaks.
- Fuel and pesticide tanks for cracks and holes.
- Pesticide hopper for cracks and holes.
- Hopper agitator for security.
- Fuel and liquid pesticide lines for cracks and holes.
- Couplings and fittings for tightness.
- Screws, nuts, and bolts for tightness.
- Unsealed lubrication points for dryness or excessive grease.
- Drive pulleys for tightness.
- Drive belts for fraying and proper tension.
- Hopper drive chain and boom steering chain for weak links and lubrication.
- Shutoff and regulating valves for operability.

Before performing the final phase in the preoperational inspection on this equipment (operational test using water or talc) you should insure that all jewelry is removed and form fitting protective clothing is worn. Clothing that is excessively loose fitting and jewelry have a tendency to be caught in drive belts, pulleys, and protruding objects which can cause serious injuries. You must also insure that no one is standing in front of the air boom or beside the air fan because the items create extreme suction and air velocity. The air boom should be pointed upward before starting this equipment.

After you have completed the first step in the preoperational inspection and have taken the prestarting precautions, start and operate the equipment to insure that there are no leaks and that all parts are operational.

Most models of this equipment are not designed to produce high pressures, because they rely on the air velocity to disperse the pesticide; therefore, you must not operate the equipment with pressures exceeding the recommendations set forth in the operation manual for the specific equipment.

Exercises (444):

1. The high velocity fan forces air through the large air discharge ____________________.

2. The liquid pesticide is forced through small nozzles into the large air discharge boom and blown from the machine as a ____________ or ____________________.

3. What parts of the electrical system should be checked?

4. The fuel pump should be checked for____________.

5. An operational check should be performed using __________________ or ________________.

6. When operating this equipment, you should remove all ____________ and wear ____________ __________________ __________________ clothing before starting this equipment.

445. Point out operational features of trailer-mounted hydraulic sprayers.

Trailer-Mounted Hydraulic Sprayer Operation. With this type of equipment the liquid pesticide formulation is pressurized by means of a power-driven hydraulic pump with suitable regulators provided to maintain the desired pressure. Pressures range from 20 to 800 psi. The spray pattern is determined by the pressure and the type of nozzle used, varying from a solid stream to a fine mist. The power sprayer has a tank of 50 to 600 gallons capacity, with a rotating agitator to keep pesticides in suspension. A gasoline motor or power takeoff operates a piston-type hydraulic pump. The power sprayers most used in Air Force pest management operations are small outfits of not more than 200-gallon capacity mounted on trailers. These sprayers deliver a maximum of 1 to 10 gallons of spray per minute and are provided with pressure regulators in order that the recommended pressure may be maintained.

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The pressure regulator is typically a large, steel ball bearing forced against a valve seat by a spring. A nut, thumb screw, or lever adjusts the spring tension to provide high or low pressure. When pressure exceeds that desired, the ball bearing is displaced and the surplus spray recirculates through the pump or is forced back into the spray tank. The power sprayer is provided with one or more hose leads to which are attached spray guns similar to those used with the small compressed air sprayers. These sprayers may also be used with the orchard gun ordinarily purchased with the sprayer. The orchard gun is adjustable to provide any pattern from a solid stream to a fine cone spray. The orchard gun, or a spray boom with several nozzles, may be used for treating dumps or other areas requiring heavy applications.

Most engines used on this type of equipment are designed to be operated at a minimum of 1800 rpm and a maximum of 2800 rpm; however, the operator's manual must be referred to and the engine should be operated according to recommendations.

Pumps should not be regulated to exceed the maximum pressure prescribed in the operator's manual. Generally speaking, pressures should not exceed 400 psi for Air Force pest management operations.

The following items should be checked when performing a preoperational inspection on the trailer-mounted hydraulic sprayer:

- Fuel level.
- Oil level.
- Carburetor air filter for cleanliness.
- Starting rope for excessive fraying.
- Engine cylinder head for foreign debris.
- Fuel and pesticide tanks for cracks and holes.
- Hoses for cracks and holes.
- Couplings and fittings for tightness.
- Screws, nuts, and bolts for tightness,
- Drive belts for fraying and proper tension.
- Drive pulleys for tightness.
- Unsealed lubrication points for dryness and excessive grease.
- Agitator for paddle condition and security.
- Shutoff and regulating valves for operability.
- Nozzles for foreign debris.

Before performing the operational test with water, you should remove all jewelry and be dressed in form fitting protective clothing. Insure that the pesticide dispersal hose and return hose are designed and capable of withstanding pressures well above the pressure range of the pump to prevent the hoses from bursting. Make sure that the spray gun and/or boom are shut off. If the sprayer contains an air dome that must be precharged, you should charge it with the amount of air specified in the operator's manual.

Exercises (445):

1. What is the range of pressures in the hydraulic sprayer and how are they controlled?

2. What is the power sprayer tank capacity?

3. How are pesticides kept in suspension?

4. Most Air Force power sprayers have a capacity of ____________ gallons and are mounted on a __________________ .

5. These sprayers deliver from ____________ to __________ gallons of spray paint per minute. minute.

6. Most engines used on this type of equipment are designed to be operated at a minimum of _______ rpm and a maximum of _______ rpm.

7. In all cases the operator's ____________ should be referred to and the engine should be _______________ accordingly.

8. Pumps should not be regulated to exceed the ____________. pressure prescribed in the operator's manual.

446. Specify operational features of nonportable thermal fog generators.

Nonportable Thermal Fog Generator Operation. These large thermal fog generators use an air-cooled motor to run the air blower, the fuel pump, and the insecticide pump—the only moving parts of the equipment. Air is delivered by a rotary air blower into the combustion chamber where it is mixed with gasoline vapor and ignited, burning into the combustion temperature of 800 to 1200° F. The hot gases then pass out of the machine through a fog head or spud. The oil solution of insecticide is pumped through the particle size selector, which is a simple delivery valve, and then is injected into a cup in the fog head or directly into the nozzle where it is vaporized by the blast of hot gases. As the hot oil vapor is discharged into the cooler outside air, it condenses, forming very small droplets or fog.

The delivery rate of the large machines normally is from 40 to 120 gallons per hour with the vehicle moving at 5 to 10 miles per hour. As the delivery rate is increased, the burner temperature is increased to assure adequate vaporization of the larger volume of insecticide solution. The smallest particles may be in the range of a smoke or fume (0.001 to 0.1 micron) and range upwards to 100 microns or more, but ideally the majority should be in the 5 to 25 microns size to kill mosquitoes and flies. There is frequently a "sorting out" of particles with the larger ones closest to the machine and the smallest ones drifting several hundred feet or more with a favorable wind.

For most routine adulticiding, No. 2 fuel oil is the preferred solvent for insecticides. Oils of higher viscosity than No. 2 diesel oil, sometimes called "fog oils," generally produce a more spectacular fog than diesel oil, but several comparative tests of these oils have shown they have no advantage over No. 2 fuel oil for killing adult mosquitoes. Since these special "fog oils" usually are higher priced, No. 2 diesel oil remains the solvent of choice for thermal fogging.

To perform a preoperational inspection on this item of equipment, you should check the following items:

- Fuel level.
- Engine oil level.
- Turbine oil level.
- Drive belts for fraying and proper tension.
- Drive pulleys for tightness.
- Fuel and insecticide hoses for cracks and holes.
- Fuel and insecticide tanks for cracks and holes.
- Couplings and fittings for tightness.
- Screws, nuts, and belts for tightness.
- Unsealed lubrication points for dryness or excessive grease.
- Shutoff and regulating valves for operability.
- Starting rope for excessive fraying.
- Fuel pump reservoir level.

Before performing the final phase of the preoperational inspection (operational test using diesel fuel only) you should remove all jewelry and be dressed in form fitting protective clothing. Make sure that no one is in front of the dispersal nozzle, and be sure that the fuel valve on top of the combustion chamber is closed. Also, insure that the insecticide regulating valve is in a closed position.

After you have performed the previous checks and have taken the necessary safety precautions, the equipment can be started.

After the thermal fogger has been started, check for leaks again while the engine is warming; then, slightly open the fuel valve on top of the combustion chamber and listen for combustion. Once combustion has been obtained, regulate the fuel pressure control valve on the front panel to obtain approximately 1200° F reading on the temperature gage.

After this has been done, open and adjust the insecticide formulation pressure control valve that is located on the front panel to obtain the density of fog that is desired.

Following the completion of all these steps, reinspect the equipment for leaks and proper functioning of gages and control valves.

Exercises (446):

1. The nonportable fog generator uses an air-cooled motor to run what components?

2. Air is delivered to the combustion chamber where it is mixed with gasoline vapor and ignited, burning at a combustion temperature of ________ to ________ °F.

3. What happens as the hot oil vapor is discharged into the cooler outside air?

4. What is the delivery rate of the large machine?

5. Ideally, the insecticide particles should range from ______________ to ______________ microns in size to kill mosquitoes and flies.

6. What is the solvent choice for thermal fogging?

7. Once combustion has been obtained, regulate the fuel pressure to obtain a temperature of ________________° F.

447. Cite operational features of nonportable mechnical aerosol generators.

Nonportable Mechanical Aerosol Generator Operation. The mechanical aerosol generator breaks up the insecticide into fine particles by mechanical pneumatic means. The insecticide can be in either a water emulsion or an oil solution. The emulsion is sometimes preferred as less likely to cause "burning" of vegetation outside, or to have less fire or explosion hazard indoors, a atomized oil soultions. In one of the mechanical fog generators, concave discs are mounted on a hollow drive shaft with a cavity between each pair of discs. Turning at high speed, the discs expel both air and liquid outward between their rims by centrifugal force. The partial vacuum, thus created, pulls liquid from the tank through the hollow drive shaft and into the cavities by means of feeder holes in the shaft. A blower on the same shaft drives the insecticide droplets away from the machine at a high velocity. Particle size depends upon the speed of rotation, the delivery rate, and the viscosity of the insecticide.

To perform a preoperational inspection on the mechanical aerosol generator, you should check the following items:

- Fuel level.
- Engine oil level.
- Battery water level.
- Battery terminals and cables.
- Blower oil level.
- Carburetor air filter for cleanliness.
- Blower screen for foreign debris.
- Unsealed lubrication points for dryness or excessive grease.
- Drive belts for fraying and proper tension.
- Drive pulleys for tightness.
- Shutoff and regulating valves for operability.
- Fuel tank for cracks and holes.
- Fuel and insecticide hoses for cracks and holes.
- Couplings and fittings for tightness.
- Screws, nuts, and bolts for tightness.
- Engine cylinder head for foreign debris.
- Fuel pump for leaks.
- Fuel sediment bowl for foreign debris.
- Nozzles for foreign debris.

Before performing the operational test on the mechanical aerosol generator, you should insure that all jewelry has been removed and form fitting protective clothing is being worn along with the required protective equipment. You must also insure that the insecticide suction hose and the return hose is submersed in a sufficient quantity of clean water.

After you have completed the previous checks and have taken the necessary safety precautions, the equipment can now be prepared for operation.

To prepare the equipment for starting, you should close the air pressure valve, turn the three-way valve to the bypass position, open the flow control valve counterclockwise one or two turns, close the fluid pump drain-cock, open the fuel shutoff valve, and prime the carburetor. Now pull out the choke control, pull the governor control one-third of the way out and lock, depress the ignition and starter switches, adjust choke for smooth operation, allow engine to warm, make necessary adjustments in the choke as the engine turns, and then lock the governor in the idle position.

While the engine is warming up reinspect the equipment for leaks. If no leaks or other malfunctions are detected at this point, the operational test can now be continued.

Obtain a reading of 5.2 inches of mercury on the manometer by regulating the engine rpm with the governor control. Once the desired reading has been obtained, lock the governor control in place and then open the air pressure valve. Adjust the flow control valve to obtain a reading of 0.6 gpm on the flow control gage. The fluid pressure gage should now have a reading of 15 to 20 psi.

The mechanical aerosol generator should now be reinspected to insure that all items are functioning properly and there are no leaks from any source.

Exercises (447):

1. How does the mechanical aerosol generator break up the insecticide into fine particles?

2. The insecticide can be either a ________________ emulsion or a ________________ solution.

3. Why is the emulsion sometimes preferred to a solution?

4. What does insecticide particle size depend on?

5. A blower drives the insecticide droplets away from the machine at a ____________ velocity.

6. During the preoperational check, a manometer reading of ________ inches of mercury should be obtained by regulating the ____________ ________________.

7. The flow control valve should be adjusted to obtain a reading of ________________ ____________ on the flow control gage.

8. The fluid pressure gage should have a reading of ______________ to ______________ psi.

448. Specify operational features of the nonportable ultra-low volume generators.

Nonportable Ultra-Low Volume Generator (ULV) Operation. This item of equipment is relatively small in comparison with the other types of nonportable equipment. The insecticide tank is generally a 5- to 16 gallon capacity tank and the equipment is usually mounted on a small half-ton pickup. The nozzles utilized on this equipment must be capable of producing droplets in the 5- to 27-micron range, as a minimum of which the average droplet size should not exceed 12 microns in diameter.

To perform a preoperational inspection on this item of equipment, you should check the following items:

- Fuel level.
- Engine oil level.
- Air pump oil level.
- Battery water level.
- Battery terminals and cables for tightness and corrosion.
- Air intake filter pad for cleanliness.
- Formulation filter for cleanliness,
- Pop safety valve for operability.
- Drive belts for excessive fraying and proper tension.
- Drive pulleys for tightness and alignment.
- Nozzles for foreign debris.
- Gasoline and insecticide tanks for cracks and holes.
- Gasoline and insecticide hoses for cracks and holes.
- Couplings and fittings for tightness.
- Screws, nuts, and belts for tightness.
- Engine cylinder head for foreign debris.
- Carburetor filter for leanness.
- Shutoff and regulating valves for operability.

Before performing the operational test on the ULV generator, you should insure that all jewelry is removed and form fitting protective clothing is worn along with the required safety protective equipment. Make sure that no one is in front of the nozzle and keep the nozzle pointed away from individuals.

Once the preoperational inspection is complete and all safety precautions have been observed, the operational test is now ready to be accomplished.

Start the engine and allow it to warm to the point of the aluminum separator being hot enough to sizzle a drop of water. While waiting for the engine to warm, reinspect the equipment for leaks, excessive vibrations, and pulley alignment.

After the engine has warmed, turn on the chemical flow switch and monitor the air pressure gage. The air pressure to the air tip should be maintained between 75 to 85 psi, and the air pressure to the formulation tank should be maintained between 12 to 17 psi. These pressures are regulated and maintained by the engine and pump rpm. The engine should normally be operated at 2500 rpm and the pump operated at approximately 900 rpm. Leaking couplings, fittings and hoses, and improper drive belt tension can cause a drop in pressure which would necessitate an increase in the engine and pump rpm.

This is just one more reason for performing the preoperational inspection and operational test on this equipment before taking it out on a job. If everything checks out okay, then the equipment is ready for use; however, if malfunctions or discrepancies are detected the item should be corrected before it is used.

Exercises (448):

1. The ULV insecticide tank has a capacity of ____________ to ____________ gallons.

2. The ULV is usually mounted on a ____________ ____________________________ .

3. The nozzles on this equipment must be capable of producing droplets in the ________ to ________ micron range.

4. The average insecticide droplet size should not exceed ____________ microns.

5. After the engine is warm, the pressure to the air tip should be maintained between ____________ and ____________ psi and the air pressure in the formulation tank should be maintained between ____________ and ____________ psi.

6. How are proper pressures maintained?

7. The engine should normally be operated at _____ rpm and the pump at ________ rpm.

8. What can cause a drop in pressure and require a higher engine rpm?

449. Match operational features with the appropriate item of nonportable powered dispersal equipment.

Operation of Nonportable Powered Dispersal Equipment. As you have noticed, the effective and safe operation of nonportable powered equipment is accomplished in the same manner as with the portable manual equipment because both are accomplished by using and following the procedures outlined in appropriate operational manuals or operational instructions.

You have also seen that there are various types of nonportable equipment used for managing pests, and for each item of equipment there are specific operational principles, preoperational checks, and safety precautions.

By reviewing objectives, 444 through 448, you will be able to identify each item of equipment with its specific operational principles, preoperational checks, and safety precautions.

Exercises (449):

Match specific features in column A below with the correct type of nonportable powered dispersal equipment in column B.

Column A	*Column B*
____ 1. Hot vapor condenses in the cool outside air, forming a fog.	a. Mist-dust blower.
____ 2. Mounted on a half-ton pickup.	b. Trailer-mounted hydraulic sprayer.
____ 3. Uses high velocity fan to force insecticides out into the control area.	c. Thermal fog generator.
____ 4. Uses both dry and liquid pesticides.	d. Mechanical aerosol generator.
____ 5. Perssure should not exceed 400 psi for Air Force operation.	e. Ultra-low volume generator.
____ 6. Insecticide may be water emulsion or an oil solution.	
____ 7. Particle size depends upon speed of rotation, delivery rate, and viscosity of insecticide.	
____ 8. Pesticides kept in suspension by a rotating agitator.	

2-3. Equipment Maintenance

Besides having to select the right equipment for the job to be done, performing preoperational and operational inspections, and having to operate equipment properly, you must also maintain pesticide dispersal equipment in peak operating condition in order to conduct effective and safe pest management programs.

Maintaining pesticidal equipment is your responsibility and must be a continuing effort on your part, because the equipment can only be as effective and safe as the condition in which you keep it maintained.

This section will identify organizational maintenance tasks that must be carried out as part of your responsibility in maintaining pesticide dispersal equipment.

450. Define organizational maintenance and list tasks related to it.

Organizational Maintenance Responsibilities. Organizational maintenance is the maintenance that is performed by personnel within the section. This includes the maintenance that is performed as operator maintenance. Organizational maintenance consists of performing all maintenance within the capability of the section. It is your responsibility; therefore, you must be knowledgeable of the common tasks that you will be required to perform. These tasks include cleaning, servicing, adjusting, repairing, replacing, and calibrating disposal equipment and/or equipment components. Remember that all maintenance must be accomplished in accordance with appropriate publications which identify the tasks and frequency of tasks to be performed.

Exercises (450):

1. Define organizational maintenance.

2. List the tasks that are included in organizational maintenance, dispersal equipment and components.

3. All maintenance must be accomplished in accordance with ______________________ .

451. List the purposes for cleaning pesticide dispersal equipment and specify the cleaning methods to be used on identified types of dispersal equipment.

Equipment Cleaning. To prolong the life of the equipment, each item must be cleaned after each use because dirt and pesticidal formulations are most damaging to protective coatings and internal portions of the equipment. Another purpose for frequent cleaning is to reduce contamination hazards. The cleaning methods used for cleaning pesticidal equipment will depend upon the type of equipment to be cleaned. These cleaning methods, along with the types of equipment that can be cleaned by each method, will now be discussed.

Flushing. Each item of equipment that is strictly designed to disperse only liquid pesticidal formulations must be flushed after each use. Flushing should be done before washing the items of equipment, because flushing after washing would redeposit pesticide particles on the exterior surfaces, which would defeat the purpose for washing.

Flushing is the term that is applied to cleaning the entire inner portions of the pesticide dispersal system to remove dirt and pesticides from the formulation tank, pump, hoses, and nozzles.

Flushing this system is very important because many pesticides are corrosive, and if left inside the system they can be very damaging.

Equipment that is designed strictly for dispersing solution-type formulations must be flushed with a solvent such as kerosene or No. 4 grade fuel oil and never with water, whereas equipment that is designed strictly for dispersing emulsion and suspension-type formulation must be flushed with water and never with a solvent. For those items of equipment that are designed to disperse solutions, emulsions, and suspensions, regular flushing with water is most practical; however, an occasional flushing with a solvent may be required especially if the equipment is being prepared for extended storage.

Washing. All items of nonportable powered equipment, along with the compressed air sprayer, pistol sprayer, knapsack sprayer,garden hose sprayer, and the frame-mounted hydraulic sprayer, can be cleaned by washing with a detergent and water solution. All exterior surfaces of the equipment must be washed after each use to remove damaging dirt and pesticide particles. Care must be taken to avoid applying water to engine components. The interior portions or dust hoppers should be washed, providing they are not to be used for several hours afterwards to allow drying time.

The equipment must be rinsed thoroughly and should be wiped dry to remove corrosive substances that may have been deposited by the water.

Triple rinsing. The triple rinse method of cleaning equipment is flushing the liquid pesticide dispersal system three times; the first two times using separate solutions of detergent and water, and the third time using water only. This method must be used to flush an item of equipment that is designed for applying solutions, emulsions, and/or suspensions prior to its being used to apply a type of pesticide different from the type of pesticide it was just previously used for applying.

Vacuuming. For items of equipment that are designed strictly for applying dusts and/or granules, cleaning should be done by vacuuming. Hoppers on other items of equipment that are used strictly for dusts and granules should also be cleaned by vacuuming.

Wiping. Wiping with a damp or dry cloth is the cleaning method that should be used to clean engines and equipment where water would be damaging and would cause the equipment to be inoperable for a period of time.

Steam cleaning. The steam cleaning method is primarily restricted to removing heavy deposits of oil and grease from nonportable powered equipment. This method is also used for cleaning nonportable powered equipment that requires field or depot maintenance prior to the equipments being forwarded for maintenance.

Waxing. All items of nonportable powered equipment should be waxed periodically to further assist in the removal of dirt and pesticide particles and to provide protection to the protective coatings.

Exercises (451):

1. List the purposes for cleaning pesticide dispersal equipment.

2. Equipment designed to disperse liquid formulations should be ______________ after each use.

3. When should flushing be done?

4. What would result if a piece of equipment were flushed after washing?

5. Flushing is used to remove pesticide from what parts of equipment?

6. With what must equipment designed strictly for solution-type formulations be flushed?

7. Equipment designed strictly for emulsion and suspension-type formulation must be flushed with ______________ and never ______________.

8. When washing equipment, care must be taken to avoid applying water to the ______________ compartment.

9. The third rinse of the triple rinse process uses ______________ only.

10. Equipment designed for applying dust or granules should be cleaned by ______________.

11. Engines should be cleaned by ______________ with a ______________ or ______________ cloth.

12. ______________ cleaning is used to remove heavy deposits of grease and oil.

13. To provide added protection, equipment should be ______________ periodically.

452. Indicate whether given statements reflect the correct practices and procedures to service equipment.

Equipment Servicing. Proper servicing is vital to the operation and maintenance of equipment, because improper servicing may cause the equipment not to operate, or if it does operate, it could be very damaging to equipment components and could present very serious hazards to the operator and others.

Fuel. The proper type and quantity of fuel must be used for each item of powered equipment. For some items of equipment a gasoline and oil mixture is required for operating the equipment. However, most equipment only requires regular gasoline as the fuel type. Do not overfill fuel tanks, especially those that are pressurized. If fuel tanks are overfilled, spillage will result due to the expansion of the fuel and the transporting of equipment.

Lubricant. There are many types of lubricants that are used in maintaining pesticidal equipment. The type of lubricant to be used depends upon the type of equipment and location of use. For this reason, you must always refer to the equipment manual.

For most items of powered dispersal equipment, SAE 30W detergent oil is normally used in the engine block. The type of oil normally used in gear boxes of equipment is SAE 90W nondetergent, and blowers normally require SAE 30W nondetergent oil. Regardless of the type of oil used or where it is used, it requires changing periodically and must be changed according to manufacturer's recommendations.

General purpose grease is normally used for lubricating shaft bearings and other movable parts that are provided with unsealed grease fittings. These items must be maintained with the appropriate amount and type of grease. These fittings should be greased just to the point before the grease begins to ooze. Sealed grease fittings require less frequent lubrication. You must never overlubricate these fittings because this will cause the seal to break and will damage the bearings.

Water. Not many items of dispersal equipment are equipped with radiators, but if they are, you must insure that the proper water level is maintained at all times. If the water level in the radiator is very low, it will cause the equipment to overheat and be damaging to the engine.

Unsealed batteries utilized on equipment must be filled to the proper level with water and maintained at this level at all times. Distilled water should be used when possible.

Air. Some types of hydraulic sprayers contain pressure domes that require precharging before operation. Precharging is done by using air to pressurize the dome with a specific amount of pressure for the desired operational pressure.

Vehicle tires must be inflated and maintained with the proper air pressure to prevent uneven wearing and blowouts.

NOTE: *Use extreme caution at all times when servicing equipment with air, and always service equipment according to the information provided in the appropriate publication.*

Exercises (452):

Identify the statements below as correct (C) or incorrect (I). Make corrections to the incorrect statements.

1. Improper servicing may cause equipment not to operate.

2. If not properly serviced, the equipment will not operate.

3. The type of fuel used in equipment is not important as long as it runs.

4. Overfilling tanks is hazardous.

5. The type of lubricant used depends on the equipment.

6. The type of oil used in gear boxes is SAE 30W detergent.

7. When greasing equipment, the grease should be applied until it begins to ooze.

8. Water is not required in dispersal equipment engines.

9. Batteries should be serviced with distilled water when possible.

10. Vehicle tires are the only components requiring air on dispersal equipment.

11. Equipment publications or TOs should always be followed when servicing equipment.

453. Point out requirements for making equipment component adjustments

Adjusting Equipment. Many items of powered dispersal equipment, especially the items of equipment that are nonportable, have several components that require adjusting. Proper adjustments must be made in order for the equipment to operate effectively and safely. All adjustments must be made in the manner specified by the appropriate equipment operation publication.

Spark plugs. Most manufacturer's operation manuals specify the frequency for inspecting, cleaning and replacing spark plugs. However, you can inspect these plugs more frequently for proper gap settings. Before installing new spark plugs into equipment, the spark gap must be adjusted by gently spreading or squeezing the ground electrode away from the center electrode or toward the center electrode.

NOTE: *When removing or installing spark plugs, use a spark plug socket wrench and apply straight and even pressure on the wrench as you turn it to avoid breaking the porcelain that surrounds the plug. Tighten the plug snuggly into the block but don't overtighten it.*

Points. Points must be adjusted according to the equipment manufacturer's specifications. Points require periodic inspections to determine their condition because burned contacts of points can and most often will cause the engine to run very rough. Points that are being installed must be adjusted after they have been placed inside the distributor by using a point gage and a screwdriver.

Carburetor. Many items of powered dispersal equipment are obtained with a preset governor to control the engine rpm. The governor should never be tampered with; however, idle screws and fuel/air mixture screws on the carburetor do require minor adjustments from time to time. These adjustments must be in accordance with the manufacturer's recommendations and can be accomplished with a small screwdriver or open-end wrench.

Control valves. Control valves require frequent adjustments, and adjustments are determined by the amount of flow desired or engine rpm desired.

Drive pulleys. Pulleys must be properly aligned on pulley shafts to prevent excessive wear to drive belts and pulley shafts. Extreme vibrations in equipment can also be caused by improperly aligned pulleys. Pulleys must be adjusted to the proper distance between pulleys to provide proper tension on drive belts. Proper adjustment of pulleys is obtained when drive belts can be depressed ¾-inch per foot distance between pulleys.

Exercises (453):

1. All equipment adjustments must be made according to the appropriate ________________.

2. When servicing spark plugs they are either __________ or replaced.

3. When spark plugs are being replaced, they should be checked for proper __________.

4. Using an improper tool on a spark plug can cause the __________ to break.

5. Points must be adjusted according to __________ __________.

6. Burned contact points cause an engine to run very __________.

7. Should the governor on an engine ever be tampered with?

8. Idle screws and fuel/air mixture screws on a carburetor will require minor __________ from time to time.

9. How are control valve adjustments determined?

10. What may cause extreme vibration in equipment?

11. Proper pulley adjustment is obtained when drive belts can be depressed __________ inch per foot between pulleys.

454. Indicate whether given statements correctly reflect policies and procedures in repairing pesticide dispersal equipment.

Equipment Repair. Repairing pesticide dispersal equipment can be a very challenging and interesting task, especially if you happen to be mechanically inclined. There are many repairs that are very simple to do, but others may be very difficult; for example, replacing a plunger cup on a compressed air sprayer is a very simple repair task, but freeing a sticking valve in an engine can be a very difficult task.

Most repairs are accomplished by either replacing parts of a component or replacing the entire component. Naturally, it is less expensive to replace parts than to replace the component; therefore, equipment should be repaired by replacing parts rather than the entire component when possible.

An adequate supply of parts and components that require frequent replacement should be maintained within the section at all times to expedite repairs to equipment. Most manufacturers of equipment provide a complete parts list in the equipment operations manual for that item of equipment to assist you in ordering replacement items. The manufacturer is the best source for obtaining parts and information pertaining to the equipment. In many cases, the manufacturer is the only source for obtaining certain parts for the equipment.

Control valves, pumps, and spray guns are equipment components that normally require frequent repairs. Generally, repairing these components requires replacing certain parts such as valve seats, O-rings, packing, gaskets, springs, gears, bearings, and pistons.

Inoperative or damaged indicator gages, shaft bearings, hoses, and drive belts are components that should always be replaced instead of repaired. When pump and control valve housings are cracked, replacement of these components is normally required.

Replacing parts in a carburetor can be very tedious and should not be attempted by an unskilled individual or without specific instructions. Repairing carburetors requires exactness.

Exercises (454):

Identify the following statements as correct (C) or incorrect (I) and correct the incorrect statements.

1. Most repairs are accomplished by replacing parts or complete components.

2. Equipment repairs should be accomplished by replacing components when possible.

3. A parts supply is not maintained within the section.

4. The manufacturer's manual usually contains a parts list.

5. Control valves, pumps, and spray guns do not usually require frequent repairs.

6. Replacing carburetor parts requires a skilled technician.

2-4. Equipment Calibration

The final step in preparing your equipment for effective and safe application of pesticides is calibrating the equipment.

You can select the right equipment for the job, have it in proper operating condition, adhere to safety precautions, and operate the equipment properly, and still not be able to do the job effectively and safely without calibrating the equipment.

Calibration is simply adjusting your equipment to apply the desired rate of pesticide. You need to do this so that you can be sure you are using each pesticide as directed on the label. Too much pesticide is dangerous; too little will not do a good job. Only by calibrating correctly can you safely get the best results.

After you have completed this section, you will understand the procedures used for calibrating equipment, which is a must for pest managers.

455. Specify procedures used for calibrating pesticide dispersal equipment.

Equipment Calibration Methods. There are many ways to calibrate equipment. The preferred methods differ according to the type of equipment that is to be used.

Calibration of sprayers. To apply a pesticide evenly and accurately, your sprayer must move at a constant speed. It also must operate at a constant pressure. Each nozzle must be clean and at the right height. All nozzles must be of the correct type and size for the job. Each nozzle in the system must deliver its rated amount of pesticide.

First, choose the speed, pumping pressure, and nozzle or nozzles that you want to use. Fill the spray tank with water and operate the sprayer in place to fill the plumbing. Top off the tank and spray a measured area as if you were applying the pesticide. Measure the amount of water needed to refill your tank. This is the application rate per unit of area. If it takes 8 gallons to refill the tank after spraying 1 acre, you are spraying at the rate of 8 gallons per acre. If your sprayer has a tank of more than 100 gallons capacity, you should spray an area large enough to use at least 10 percent of the tank capacity.

If your sprayer is delivering more or less spray than the label directs, you can change the rate three ways:

(1) You can change the pressure. Lower pressure means less spray delivered; higher pressure means more spray delivered. This is not a good method, because a pressure change may change the nozzle pattern and droplet size. Pressure must be increased four times to double the output.

(2) You can change the speed of your sprayer. Slower speed means more spray delivered; faster speed means less spray delivered. This method is practical for small changes in delivery rate. If you drive half as fast, you double the delivery rate.

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(3) You can change the nozzle tips to change the amount delivered. The larger the hole in the tip, the more spray delivered. This is the best method of making major changes in the delivery rate of sprayers. Always select nozzles for the job you want done. Use the manufacturer's performance charts to make your selection.

After making a change, you must recalibrate your sprayer to make sure the rate is correct.

You have adjusted your sprayer, and you know how many gallons of spray per unit of area your equipment will apply. Next, you must find out how much pesticide to put in the tank to apply the correct dosage of pesticide. To do this you need to know two more facts:

- How much your sprayer tank holds.
- The amount of formulation to be used per unit of area. This will be given on the label.

Suppose your tank holds 50 gallons of spray. The directions say to apply 1 pint of formulation on each acre. In our example, you found that your sprayer applies 8 gallons per acre. First, find the number of acres one tank load will spray. Divide 50 gallons by 8.

$$\frac{\text{50 gallons per tankful}}{\text{8 gallons per acre}} = 6\ \tfrac{1}{4}\ \text{acres per tankful}$$

To find the amount of formulation, you must add to your tank so you can spray 6 ¼ acres with 1 pint per acre, multiply 1 pint by 6 ¼.

1 pint per acre × 6¼ acres per tankful = 6¼ pints per tankful.

Suppose the formulation of a pesticide is a 50 percent wettable powder and you want to apply ½ pound of active ingredient per acre. In our example, your tank will cover 6¼ acres.

Find how many pounds of formulation are needed to apply ½ pound of active ingredient per acre. There is ½ pound of active ingredient in 1 pound of 50 percent wettable powder formulation. So you need to use 1 pound of formulation for each acre your sprayer will cover.

1 pound per acre × 6¼ acres per tankful = 6¼ pounds per tankful.

You should add the 6¼ pounds of wettable powder to a small amount of water in a clean bucket. Stir until it is mixed well, and then add this mixture (called a slurry) to the partly filled tank. Remember to operate the sprayer's agitator while adding the slurry and filling the tank.

Even after your sprayer is calibrated, you should recheck it often. Be sure you are spraying the same size area for each tankful as you figured on. If you are spraying more or less acres than you planned, stop spraying and recalibrate. If you have figured wrong or your sprayer changes its delivery rate, you will be able to catch it before you make a major mistake.

Calibration of dusters and granular applicators. These items of equipment are calibrated as follows:

- Read the manufacturer's operator's manual. Follow these instructions to set the gate openings for the product you are going to use.

CAUTION: Always set the openings from the same direction, such as from closed to open. This will minimize variations in settings.

- Fill each hopper to an easily determined level.
- Operate the equipment over a measured area or distance at your normal working speed. The area should be large enough to use 25 percent of the hopper contents.
- Refill the hopper to the same level, weighing the amount of pesticide needed to replace what was used.
- The amount of pesticide it takes to refill the hopper is the amount applied to the measured area. If the amount applied does not fall within 5 percent of the recommended dosage per unit of area, reset the gate opening and repeat the previous three steps.
- Keep a record of the area treated with each filling of the hopper. This will let you see any slight change in rate of application and make the necessary adjustments.

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Exercises (455):

1. What is required to apply a pesticide evenly and accurately?

2. If your sprayer has a tank capacity of 100 gallons or more, you should spray an area large enough to use how much of the tank capacity?

3. What is the best method of changing the delivery rate?

4. What is a pesticide slurry made of?

5. When setting the gate opening of a duster or granular pesticide applicator, you should use approximately __________________ of the hopper capacity and then check again.

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Answers for Exercises

CHAPTER I

Reference

400 - 1. Herbicide.
400 - 2. Ovicide insecticide.
400 - 3. Contact.
400 - 4. Rodenticide.
400 - 5. Adulticide, insecticide, contact.
400 - 6. Preemergence herbicide.
400 - 7. Arachnicide.
400 - 7. Stomach.

401 - 1. Plant; animal; mineral.
401 - 2. Organic.
401 - 3. Paris green.
401 - 4. DSMA.
401 - 5. Postemergence.
401 - 6. Insure that these compounds do not contaminate any water source during or after application.

402 - 1. a. 4.
b. 3.
c. 1.
402 - 2. Because they break down within the environment.
402 - 3. SMDC.
402 - 4. It may cause staining and odor problems.
402 - 5. Cholinesterase.
402 - 6. Propoxur.
402 - 7. a. Wear protective clothing and equipment.
b. Observe the rule of no smoking, eating, or drinking while handling these compounds.
402 - 8. Standard.

403 - 1. Organic, plants.
403 - 2. Pyrethrum is unstable and is readily decomposed by alkalies, light, and air.
403 - 3. Strychnine.
403 - 4. Contact; fumigating.
403 - 5. Nicotine sulfate.
403 - 6. Pyrethrum.
403 - 7. Avoid contamination of all food and water sources.

404 - 1. Because all of them contain chlorine, hydrogen, and carbon.
404 - 2. Because they are very persistent.
404 - 3. Methoxychlor.
404 - 4. They are produced synthetically from plant and animal (organic) matter.
404 - 5. a. Certified personnel.
b. Personnel under the direct supervision of certified personnel.
404 -6. a. 4
b. 2
c. 1
d. 3

405 - 1. They are produced synthetically and are basically derived from phosphoric acid.
405 - 2. 1970s.
405 - 3. Resistant.
405 - 4. Organophosate compounds are biodegradable and are nonaccumulative in the body of humans.
405 - 5. Malathion; parathion; diazinon.
405 - 6. a. Malathion.
b. Dichlorvos.
c. Naled.
d. Diazinon.
e. Dursban.
405 - 7. a. 3.
b. 2.
c. 6.
d. 7.
e. 1.
f. 5.
g. 4.

406 - 1. Translocated, sterilants.
406 - 2. PBA and 2,3,6,−TBA.
406 - 3. Dicamba.
406 - 4. Dicamba.
406 - 5. Wear protective equipment and clothing.

407 - 1. Sodium salt, selective translocative.
407 - 2. Preemergence, postemergence.
407 - 3. TCA.
407 - 4. Grasses.
407 - 5. a. Do not apply near desired vegetation.
b. Do not apply near irrigation water.
c. Do not apply when heavy rains are expected.
407 - 6. Washed, corrosive.

408 - 1. Moderately.
408 - 2. a. They are not likely to cause irritation to skin or eyes.
b. They are not absorbed through the skin to any appreciable extent.
c. The amounts likely to be inhaled are not hazardous.
d. Ingestion of harmful amounts is not likely.
408 - 3. Herbaceous, broad-leaved.
408 - 4. Silvex.
408 - 5. Brush killer.
408 - 6. Aquatic.
408 - 7. Ester.
408 - 8. MCPA.

409 - 1. Used as soil sterilants.
409 - 2. a. 2.
b. 1.
c. 3.
409 - 3. Monuron, diuron.
409 - 4. a. Wear protective equipment and clothing while handling these compounds.

b. Avoid damage to desirable plants and contamination of water sources.

410 - 1. Soil sterilants.
410 - 2. Simazine.
410 - 3. Simazine.
410 - 4. Atrazine.
410 - 5. Simazine.

411 - 1. a. They are yellow dyes.
b. They are not soluble in water but are soluble in oil.
411 - 2. They are highly poisonous if swallowed, absorbed, or inhaled.
411 - 3. Nonselective contact, herbaceous.
411 - 4. DNAP; DNBP; DNC.
411 - 5. Because of this toxicity and impracticality.

412 - 1. Rodenticides, blood clots.
412 - 2. By reducing the clotting ability of the blood which causes internal and external hemorrhaging and eventually death.
412 - 3. a. Anticoagulants must be ingested in small amounts for several days before they become effective.
b. Cause no pain to the rodents.
c. Bait shyness is avoided.
412 - 4. Cumafuryl (or Fumarin).
412 - 5. Diphacinone (or Diphacin).
412 - 6. Hydroxycoumarin (or warfarin).
412 - 7. Pival.
412 - 8. Pival.
412 - 9. Diphacin.
412 - 10. Seven.

413 - 1. e.
2. c.
3. f.
4. b.
5. d.
6. g.
7. a.
8. Sodium monofluoroacetate.
9. Sodium monofluoroacetate.
10. Thallium sulfate.
11. Tartar emetic.

414 - 1. a. (1) Heavier than air.
(2) Odorless.
(3) Nonflammable.
(4) Gas fumigant.
b. (1) Treating for dry wood termites.
(2) As a herbicide to kill seeds, nematodes, and soil fungi.
c. Standard stock item.
d. (1) Protective clothing and equipment to include a gas mask and cannister that is appropriate for the fumigant.
(2) Avoid explosions and fires.
(3) Post warning signs and seal off area.
414 - 2. a. (1) Has rapid molecular action.
(2) Highly explosive.
b. Used for fumigating stored products pests in non-perishable subsistence items in transit and in place.
c. Standard stock item.
d. (1) Wear protective equipment and clothing when entering or clearing.
(2) Avoid explosion and remove all gold items.
(3) Post warning signs.
414 - 3. a. (1) Greyish-white compound.
(2) Powdered or granular form.
(3) Produces hydrocyanic acid.
b. Gassing rodent burrows.
c. Standard stock item.
d. (1) Must stand upwind and have appropriate gas mask and cannister available.
(2) Must not use near buildings occupied by people.

415 - 1. e.
415 - 2. a.
415 - 3. d.
415 - 4. f.
415 - 5. h.
415 - 6. c.
415 - 7. g.
415 - 8. b.
415 - 9. h.
415 - 10. i.

416 - 1. i.
416 - 2. g.
416 - 3. h.
416 - 4. c.
416 - 5. a.
416 - 6. f.
416 - 7. e.
416 - 8. d.
416 - 9. b.

417 - 1. Square foot formula for triangles
$X = B \times P \times 0.5$
$X = 60 \times 100 \times 0.5$
$X = 3000$ (Answer: 3000 sq ft)
417 - 2. Square foot formula for circles
$X = \pi R2$
$X = 3.14 \times 50 \times 50$
$X = 7850$ (Answer: 7,850 sq ft)
417 - 3. Square foot formula for rectangles
$X = W \times L$
$X = 5 \times 70$
$X = 350$ (Answer: 350 sq ft)
417 - 4. Cubic foot formula
$X = W \times L \times H$
$X = 30 \times 70 \times 80$
$X = 37{,}800$ (Answer: 37,800 sq ft)

418 - 1. Formula for rectangular containers
$X = L \times W \times D \times 0.004329$
$X = 4 \times 3 \times 1.5 \times 0.004329$
$X = 48 \times 36 \times 18 \times 0.004329$
$X = 134.649$ (Answer: 134.65 gallons)
418 - 2. Formula for cylindrical containers
$X = L \times D2 \times 0.0034$
$X = 4 \times 3 \times 3 \times 0.0034$
$X = 48 \times 36 \times 36 \times 0.0034$
$X = 211.507$ (Answer: 211.51 gallons)

419 - 1. $X = 0 \times \frac{60}{16}$
$X = 93 \times \frac{60}{16}$

$X = \frac{5580}{16}$
$X = 348.75$ (Answer: 348.75 pounds)
419 - 2. $\text{Speed} = \frac{\text{dispersal rate per hour}}{\text{quantity per mile}}$
$\text{Speed} = \frac{35}{7}$
$\text{Speed} = 5$ (Answer: 5 miles per hour)
419 - 3. In solving this problem, you should use two steps. The first step is to determine the total square feet within the area and the second step is to determine the total amount of finished product that is required.
Step 1: The totel square feet within the area to be treated is determined by using the square foot formula for rectangles in objective 417.
Formula: Total square feet = width × length
$X = W \times L$

X = 10 feet × 3 miles (miles must be converted into linear feet by multiplying 3 × 5,280)
X = 10 × 15,840
X = 158,400 (Answer for step 1; 158,400 sq ft)

Step 2: Indetermining the total amount of finished product that is required, the formula for calculating quantity of finished product should be used.

Formula: Quantity required

$$= \frac{\text{square feet} \times \text{quantity per acre}}{43{,}560 \text{ (square feet in an acre)}}$$

$$= \frac{158{,}400 \text{ (from step 1)} \times 75}{43{,}560}$$

$$= \frac{11{,}880{,}000}{43{,}560}$$

= 272.72 or 273
(Answer: 273 gallons of finished product)

419 - 4. Speed in feet per minute.

$$= \frac{43{,}560 \times \text{lb dispersed per min.}}{\text{Swath width} \times \text{lb dispersed per acre}}$$

$$= \frac{43{,}560 \times 8}{3750}$$

= 92,928
Speed in miles per hour = 1.056 (92,928 ÷ 88)
(Answer: 1.06 mph)

419 - 5. Quantity rate per acre

$$= \frac{43{,}560 \times \text{quantity dispersed per min.}}{\text{Swath width} \times \text{speed in feet per min.}}$$

$$= \frac{43{,}560 \times 4}{90 \times 440}$$ (5 mph converted into feet per minute)

$$= \frac{174{,}240}{39{,}600}$$

= 4.4 (Answer: 4.4 pounds per acre)

420 - 1. SAC formula (*Example* 4)

$$Q = \frac{S \times A}{C}$$

$$Q = \frac{1 \times 200}{20}$$

$$Q = \frac{200}{20}$$

Q = 10 (Answer: 10 gallons)

420 - 2. SAD SAC formula (*Example* 6)

$$Q = \frac{S \times A \times D}{C}$$

$$Q = \frac{0.5 \times 100 \times 8.34}{25}$$

$$Q = \frac{417}{25}$$

Q = 16.68 (Answer: 16.68 pounds)

420 - 3. SAD COW formula (*Example* 9)

$$Q = \frac{S \times A \times D}{CO \times W}$$

$$Q = \frac{1 \times 50 \times 8.34}{100 \times 1.5}$$

$$Q = \frac{417}{150}$$

Q = 2.78 (Answer: 2.78 gallons)

420 - 4. Proportional formula

$$X = \frac{C}{S} - 1$$

$$X = \frac{0.5}{0.025} - 1$$

$$X = \frac{20}{1} - 1$$

$$X = \frac{19}{1}$$ (Answer: 1 to 19 ratio)

420 - 5. SAC formula (*Example* 3)

$$Q = \frac{S \times A}{C}$$

$$Q = \frac{2 \times 5}{25}$$

$$Q = \frac{10}{25}$$

Q = 0.4 pounds (Answer: 6.4 ounces)

420 - 6. SAD SAC formula (*Example* 6)

$$Q = \frac{S \times A \times D}{C}$$

$$Q = \frac{1 \times 2 \times 8.34}{10}$$

$$Q = \frac{16.68}{10}$$

Q = 1.668 (Answer: 1.67 pounds)

421 - 1. Product rate formula for liquids
Product rate per acre

$$= \frac{\text{standard rate per acre}}{16 \text{ or AI per gal}}$$

$$= \frac{5}{2}$$

= 2.5 (Answer: 2.5 gallons)

421 - 2. In solving this problem, you should use two steps. The first step is to determine the acre-feet of water contained in a body of water and the second step is to determine the total product of herbicide required to treat the body of water.

Step 1: Acre-feet of water formula
Acre-feet of water = surface acres × average depth
Acre-feet of water = 12 × 5
Acre-feet of water = 60
Step 2: Quantity of total product for ppm application formula
Total product = Parts per million × acre-feet of water × 2.7
Total product = 2 × 60 × 2.7
Total product = 324 (Answer: 324 pounds)

421 - 3. Product rate formula for dry formulations

$$\text{Product rate per acre} = \frac{100}{\%AI} \times \text{standard rate per acre}$$

$$\text{Product rate per acre} = \frac{100}{75} \times 5$$

$$\text{Product rate per acre} = 6.666$$

(Answer: 6.67 pounds)

422 - 1. 1. b.
422 - 2. e.
422 - 3. a.
422 - 4. d.
422 - 5. c.
422 - 2. 100 microns.
422 - 3. Size.
422 - 4. Increase.

423 - 1. Ecology is defined as the study of the relationship of living things, the environment they live in, and their relation to other living things.
423 - 2. It is a very thin layer of life within the environment and consists of biotic and abiotic elements.
423 - 3 Carbon.
423 4. Green plants transpose carbon dioxide into oxygen which is required by animals; the animals then expel carbon dioxide which is required by plants.
423 - 5. They provide nonliving elements that are essential for growth and development of living elements.
423 - 6. Green plants and consumers of green plants.
423 - 7. Green plants.
423 - 8. Animals provide essential organic matter to the soil to support plant growth.
423 - 9. Phytoplanktons consist of green plants and consumers of green plant matter and produce 70 percent of the earth's

organisms that float about in various bodies of water.
423 - 10. Bacteria, fungi, and protozoa act as decomposers of plants and animals which return essential organic matter to the soil to support more plant growth; which in turn, supports animal growth.

424 - 1. a. Food production.
b. Property protection.
c. National prosperity.
424 - 2. a. Reduces arthropod related diseases.
b Reduces venomous arthropods.
424 - 3. Only if pesticides were continually used without proper knowledge of their hazards and without concern.
424 - 4. The effect they may have on nontarget organisms.
424 - 5. Direct application, drift, and rain.
424 - 6. Rain can contaminate soil with pesticides by cleansing the atmosphere, trees, shrubs, grasses, and structures of suspended particles.
424 - 7. One that does not break down easily or quickly.
424 - 8. The toxicity level can increase, through the series of eating and being eaten, to the point of causing many ill effects to the body and possible death.
424 - 9. Toxic, original.
425 - 1. a. Determine if pest management programs are required.
b. If requirement exisits, implement preventive and corrective nonchemical control when possible.
c. If chemical controls are required, implement safe and effective chemical controls.

425 - 2 Surveying.
425 - 3. Only after it has been determined that natural controls will not be adequate.
425 - 4. Preventive and corrective nonchemical controls.
425 - 5. Yes.
425 - 6. Because they are designed to forestall the buildup of pest populations and they are almost always more effective and economical in the long run.
425 - 7. Timely, sustained.
425 - 8. Because of inadequate or improper mechanical measures or because of natural disasters and migrating pest invasions.
425 - 9. Type, location.
425 - 10. It is of utmost importance to mix and apply pesticides in accordance with the pesticide label.

426 - 1. a. Use pesticides only when absolutely necessary.
b. Adhere strictly to label instructions.
426 - 2. The ability of a pest population to withstand pesticide treatments that were generally lethal to earlier populations.
426 - 3. The ability of one or more pests within a pest population to withstand pesticide treatments that are lethal to others within the population.
426 - 4. Habitat; avoidance.
426 - 5. Inherited; acquired.
426 - 6. a. Poison is absorbed too slowly to receive a lethal dose by some members of a pest population.
b. The ability to effect alternate functions of body systems by some members of a pest population.

427 - 1. The likelihood that the compound will cause death or injury in a given situation.
427 - 2. The ability of a compound to cause death or injur when used in a particular way or place.
427 - 3. It means the lethal dose of toxicant required to kill 50 percent of the test animals expressed in milligrams of toxicant per kilograms of body weight.
427 - 4. 50, 500 mg/kg.
427 - 5. After the approximate amount of toxicant required to kill has been determined on single test animals, a series of tests are conducted on groups of animals that are as close to being identical as possible with appropriate interim adjustments being made in toxicant dosages until 50 percent of the test animals within each of several test groups are killed.
427 - 6. In the exposure routes.
427 - 7. Less.
427 - 8. Moderately, low-order.

CHAPTER 2

428 - 1. Because different pests require different controls and therefore require different types of equipment.
428 - 2. Environmental conditions such as wind velocity, water sources, and the presence of beneficial plants and animals must be considered when selecting equipment.
428 - 3. Effective, safest.
428 - 4. Available, effectively, safely.
428 - 5. Safe.
428 - 6. Cost, cheap.
428 - 7. Durable.

429 - 1. f.
429 - 2. d.
429 - 3. a.
429 - 4. g.
429 - 5. e.
429 - 6. c.
429 - 7. b.

430 - 1. e.
430 - 2. a.
430 - 3. g.
430 - 4. b.
430 - 5. f.
430 - 6. d.
430 - 7. c.

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431 - 1. c.
431 - 2. b.
431 - 3. d.
431 - 4. a.
432 - 1. c.
432 - 2. f.
432 - 3. a.
432 - 4. b.
432 - 5. e.
432 - 6. d.

433 - 1. Polyethylene.
433 - 2. Packing material.
433 - 3. Sand snake.
433 - 4. Tape measure.
433 - 5. Fans.
433 - 6. Aluminum tray.
433 - 7. Metering.
433 - 8. Tray.
433 - 9. In a moisture permeable envelope.
433 - 10. Fumigated.
433 - 11. Respiratory.

434 - 1. c.
434 - 2. d.
434 - 3. a.
434 - 4. b.

435 - 1. Carbide exploders, revolving flashers, and sound recorders.
435 - 2. Base commander.
435 - 3. Quick.
435 - 4. Dart.
435 - 5. Poured.
435 - 6. Dragging, laying.
435 - 7. By using drip cans.
435 - 8. Paint brushes.

436 - 1. a. 4
    b. 1
    c. 2
    d. 2, 3, 4
    e. 1
    f. 4
    g. 2, 3
436 - 2. a. Type of pump.
    b. Pesticide formulation.
    c. Pressures.
    d. Corrosion, abrasion.
    e. Dry, restricted.

437 - 1. d.
437 - 2. b.
437 - 3. e.
437 - 4. a.
437 - 5. c.

438 - 1. c.
438 - 2. b.
438 - 3. d.
438 - 4. a.

439 - 1. Technical orders, technical manuals, NAV DOCS, technical information memorandums, commercial manuals, standard operating procedure, and operational instructions.

439 - 2. a. True
    b. False
    c. True
    d. True
    e. True

440 - 1. To determine if the equipment is operational.
440 - 2. Before each use.
440 - 3. You must perform a preoperational inspection.
440 - 4. That the equipment can be operated correctly and safely.
440 - 5. To reflect a true professional pest manager.

441 - 1. c, j.
    2. f, i.
    3. j.
    4. e.
    5. a, h.
    6. d.
    7. b.

442 - 1. To facilitate treatment of overhead beams and rafters.
442 - 2. Checking the rubber cylinder for cracking and splitting.
442 - 3. Insure that the bulb is not cracked and the nozzle is fitted tightly and is not clogged.
442 - 4. Siphon atomizer pump assembly.
442 - 5. Keep the wind to your back and let the dust blow downwind from you.
442 - 6. Fumigating rodent burrows.
442 - 7. Normal walking step taken.

443 - 1. b.
443 - 2. d, f.
443 - 3. e, g.
443 - 4. a.
443 - 5. c.

444 - 1. Boom.
444 - 2. Spray, mist.
444 - 3. The battery water level, and the terminals and cables.
444 - 4. Leaks.
444 - 5. Water, talc.
444 - 6. Jewelry, form fitting protective clothing.
444 - 7. Upward.

445 - 1. 20 to 800 psi, they are controlled by suitable regulators.
445 - 2. 50 to 600 gallons.
445 - 3. By a rotating agitator.
445 - 4. 200, trailer.
445 - 5. 1, 10.
445 - 6. 1800, 2800.
445 - 7. Manual, operated.
445 - 8. Maximum.

446 - 1. The air blower, the fuel pump, and the insecticide pump.
446 - 2. 800, 1200.
446 - 3. It condenses, forming very small droplets or fog.
446 - 4. It is normally 40 to 120 gallons per hour with the machine moving at 5 to 10 miles per hour.
446 - 5. 5, 25.
446 - 6. No. 2 diesel oil.
446 - 7. 1200.

447 - 1. By mechanical pneumatic means.
447 - 2. Water, oil.
447 - 3. It is less likely to cause burning of vegetation or to have less fire or explosion hazard.
447 - 4. Speed of rotation, delivery rate, and viscosity of insecticide.
447 - 5. High.
447 - 6. 5.2, engine rpm.
447 - 7. 0.6 gpm.
447 - 8. 15, 20.

448 - 1. 5, 16.
448 - 2. Half-ton pickup.
448 - 3. 5, 27.
448 - 4. 12.
448 - 5. 78, 85, 12, 17.
448 - 6. By the engine and pump rpm.
448 - 7. 2500, 900.
448 - 8. Leaking coupling, fittings and hoses, and loose belts.

449 - 1. c.
449 - 2. e.
449 - 3. a.
449 - 4. a.
449 - 5. b.
449 - 6. d.
449 - 7. d.
449 - 8. b.

450 - 1. Maintenance performed by personnel within the section, and includes operator maintenance.
450 - 2. Cleaning, servicing, adjusting, repairing, replacing, and calibrating.
450 - 3. Appropriate publications.

451 - 1. a. Prevent damage to protective coatings and internal parts.
b. Reduce contamination hazards.
451 - 2. Flushed.
451 - 3. Prior to washing.
451 - 4. Pesticide particles would redeposit on exterior surfaces.
451 - 5. Formulation tank, pump, hoses, and nozzles.
451 - 6. With kerosene or No. 4 grade fuel oil, never with water.
451 - 7. Water, solvent.
451 - 8. Engine.
451 - 9. Water.
451 - 10. Vacuuming.
451 - 11. Wiping, damp, dry.
451 - 12. Steam.
451 - 13. Waxed.

452 - 1. C.
452 - 2. I, the equipment may operate but could be damaged.
452 - 3. I, some equipment requires special fuels or a mixture of gasoline and oil; failure to use the proper fuel cause damage.
452 - 4. C.
452 - 5. C.
452 - 6. I, SAE 90W nondetergent for gear boxes; SAE 30W detergent for crankcases.
452 - 7. I, Only on unsealed fittings.
452 - 8. I, Some engines are liquid cooled, and water levels must be maintained.
452 - 9. C.
452 - 10. I, Some hydraulic sprayers have pressure domes requiring air.
452 - 11. C.

453 - 1. Publication.
453 - 2. Adjusted.
453 - 3. Gap.
453 - 4. Porcelain.
453 - 5. Equipment manufacturer's specifications.
453 - 6. Rough.
453 - 7. No.
453 - 8. Adjustments.
453 - 9. By the amount of flow desired or engine rpm desired.
453 - 10. Improperly aligned pulleys.
453 - 11. 3/4.

454 - 1. C.
454 - 2. I, Parts should be replaced when possible since it is less expensive.
454 - 3. I, Parts should be kept on hand to expedite repairs.
454 - 4. C.
454 - 5. I, These items usually do require frequent repairs.
454 - 6. C.

455 - 1. Your sprayer must move at a constant speed.
455 - 2. At least 10 percent.
455 - 3. Change the nozzle tips.
455 - 4. Wettable powder and water.
455 - 5. 25 percent.

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S T O P - 1. MATCH ANSWER SHEET TO THIS EXERCISE NUMBER.
2. USE NUMBER 2 PENCIL ONLY.

EXTENSION COURSE INSTITUTE
VOLUME REVIEW EXERCISE
56650 03 21
PEST MANAGEMENT, CHEMICALS AND EQUIPMENT

Carefully read the following:

DO's:

1. Check the "course," "volume," and "form" numbers from the answer sheet address tab against the "VRE answer sheet identification number" in the righthand column of the shipping list. If numbers do not match, take action to return the answer sheet and the shipping list to ECI immediately with a note of explanation.
2. Note that item numbers on answer sheet are sequential in each column.
3. Use a medium sharp #2 black lead pencil for marking answer sheet.
4. Write the correct answer in the margin at the left of the item. (When you review for the course examination, you can cover your answers with a strip of paper and then check your review answers against your original choices.) After you are sure of your answers, transfer them to the answer sheet. If you have to change an answer on the answer sheet, be sure that the erasure is complete. Use a clean eraser. But try to avoid any erasure on on the answer sheet if at all possible.
5. Take action to return entire answer sheet to ECI.
6. Keep Volume Review Exercise booklet for review and reference.
7. If mandatorily enrolled student, process questions or comments through your unit trainer or OJT supervisor. If voluntarily enrolled student, send questions or comments to ECI on ECI Form 17.

DON'Ts:

1. Don't use answer sheets other than one furnished specifically for each review exercise.
2. Don't mark on the answer sheet except to fill in marking blocks. Double marks or excessive markings which overflow marking blocks will register as errors.
3. Don't fold, spindle, staple, tape, or mutilate the answer sheet.
4. Don't use ink or any marking other than a #2 black lead pencil.

NOTE: NUMBERED LEARNING OBJECTIVE REFERENCES ARE USED ON THE VOLUME REVIEW EXERCISE. In parenthesis after each item number on the VRE is the Learning Objective Number where the answer to that item can be located. When answering the items on the VRE, refer to the Learning Objectives indicated by these Numbers. The VRE results will be sent to you on a postcard which will list the actual VRE items you missed. Go to the VRE booklet and locate the Learning Objective Numbers for the items missed. Go to the text and carefully review the areas covered by these references. Review the entire VRE again before you take the closed-book Course Examination.

MULTIPLE CHOICE

1. (400) Which insect stages are usually controlled with insecticide?

   a. Pupal and adult.
   b. Egg and larval.
   c. Larval and adult.
   d. Egg and pupal.

2. (400) Which one of the following systems is attacked by fumigants?

   a. Digestive.
   b. Nerve.
   c. Circulatory.
   d. Respiratory.

3. (401) Which one of the following pesticides is a postemergence herbicide and a standard stock item?

   a. Copper aceto-meta-arsenite (paris green).
   b. Disodium monomethylarsonate (DSMA).
   c. Monosodium methanearsonate (MSMA).
   d. Ammonium methanearsonate (AMA).

4. (401) Inorganic arsenicals are undesirable for use as pesticides because they

   a. remain stable for long periods of time.
   b. are too short lived.
   c. are ineffective for many pests.
   d. are very difficult to apply.

5. (402) How do carbamates differ from hydrocarbon and organophosphate insecticides?

   a. By their chlorine and phosphorus content.
   b. They contain hydrogen instead of nitrogen.
   c. They are noncontact insecticides.
   d. By their lack of chlorine and phosphorus.

6. (403) Strychnine is used to control which of the following?

   a. Rodents.
   b. Plants.
   c. Insects.
   d. Arachnids.

7. (404) Which of the following organochlorines is considered the safest insecticide?

   a. Chlordecone.
   b. Methorychlor.
   c. Lindane.
   d. Chrordane.

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8. (405) Which of the following insecticides can be incorporated into resin stripes to give off toxic vapors for long periods of time?

   a. Dichlorvas.
   b. Malathion.
   c. Dimethorte.
   d. Naled.

9. (405) Which of the following insecticides has been limited to tick and mite control?

   a. Parathion.
   b. Rabon.
   c. Ronnel.
   d. Fenthion.

10. (406) Which of the following pests is controlled by the use of benzoic acid compounds?

    a. Spiders and mites.
    b. Mosquitoes and flies.
    c. Perennial and annual weeds.
    d. Cockroaches and bedbugs.

11. (406) What precautions must be taken when using benzoic acid solutions?

    a. Be alert for fire and explosion.
    b. Do not use on broad leaf plants.
    c. Apply on windy days to insure good coverage.
    d. Wear protective clothing and avoid drifts.

12. (407) Aliphatic Acid herbicides should not be used when heavy rains are expected because they

    a. will be diluted and ineffective.
    b. leach out of top soils and affect other areas.
    c. are incompatible with water and become poison to animals.
    d. will increase in strength and kill all vegetation.

13. (408) The phenaxy formulations are

    a. moderately toxic.
    b. corrosive.
    c. highly toxic.
    d. nontoxic.

14. (408) 2, 4-D is commonly used as a

    a. soil sterilant.
    b. general herbicide.
    c. selective herbicide.
    d. combination herbicide and insecticide.

15. (409) Phenylureas are used as

a. general herbicides.
b. selective herbicides.
c. growth retardants.
d. soil sterilants.

16. (409) What type of soil is best suited for the application of monuron?

a. Sandy soils with high organic content.
b. Sandy soils with high mineral content.
c. Tight clay soils with high mineral content.
d. Tight clay soils with high organic content.

17. (410) When is Simazine most desirable to use as a soil sterilant?

a. When you do not want to kill aquatic plants.
b. When selected plants are to be killed.
c. Where the soil has a high clay content.
d. Where any plant growth is undesirable.

18. (410) Atrazine is more effective in dry areas than Simazine because Atrazine is

a. less soluble.
b. more penetrating.
c. more soluble.
d. less penetrating.

19. (411) The parent compounds of Dinitros are dissolved in

a. oil.
b. water.
c. acetone.
d. salt water.

20. (412) What is the advantage of using anticoagulants for killing rodents?

a. Small dosage reduces hazards to humans and domestic animals.
b. They are not toxic to humans and domestic animals.
c. Only one dose is necessary.
d. Rodents shy away from it once they are affected and leave the premises.

21. (412) The precipitation of pival from natural water can be prevented by

a. continuous agitation.
b. adding sodium salt.
c. adding a stabilizing agent.
d. using distilled water.

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22. (413) What is one of the greatest hazards of sodium monofluoracetate (compound 1080)?

    a. It is very volatile.
    b. It is absorbed by the skin.
    c. There is no known antidote.
    d. Rodents carry the poison to other animals.

23. (413) The purpose of using an ultraviolet light screening agent in Resmethrin is to

    a. make it easy to find in the dark.
    b. prevent the breakdown of the material.
    c. decrease the life of the material.
    d. make the material more attractive to rats.

24. (414) Which of the following fumigants is used to kill rodents in their burrows?

    a. Naphthalene.
    b. Aluminum phosphide.
    c. Dichlorvas.
    d. Calcium cyanide.

25. (414) Which of the following fumigants is used to control vegetation?

    a. Aluminum phosphide.
    b. SMDC (vapam).
    c. Calcium cyanide.
    d. Paradichlorobenzene.

26. (414) What is added to methyl bromide to act as a warning agent?

    a. Sulfuryl fluouride.
    b. Aluminum phosphide.
    c. Calcium cyanide.
    d. Chloropicrin.

27. (415) A substance that produces sensory stimulation is called

    a. an attractant.
    b. a dissicant.
    c. a solvent.
    d. an emulsifier.

28. (415) Sulfonated oils are used as a

    a. sticking agent.
    b. masking agent.
    c. wetting agent.
    d. synergist agent.

29. (415) Which item may be used to counteract the resistance of insects to certain chemicals?

    a. Emulsifiers.
    b. Wetting agents.
    c. Synergists.
    d. Diluents.

30. (415) Select a desirable characteristic of a carrier.

a. The carrier must produce a wettable powder.
b. The carrier must improve the adhesive quality of the insecticide.
c. The carrier must dissolve the high concentration of pesticides.
d. The carrier must not produce any breakdown of the pesticidal chemical.

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31. (416) The purest commercial form of a pesticide is

a. a dust.
b. granules.
c. crystalized.
d. technical grade.

32. (416) Pesticidal granules are used to

a. penetrate dense foilage.
b. stick on vertical surfaces.
c. cover porous surfaces.
d. cover metal surfaces.

33. (416) Solution concentrates that are diluted at their destination are called

a. emulsifiable solutions.
b. field strength solutions.
c. anticaking solutions.
d. wettable powder.

34. (416) Emulsifiable concentrates consist of a

a. field strength solution, wettable powders, and an emulsifying agent.
b. technical grade pesticide, an inert carrier, and a solvent.
c. technical grade pesticide, a solvent, and an emulsifying agent.
d. wettable powder, water, and a solvent.

35 (416) Emulsions or solutions diluted to field strength are called

a. emulsifiable concentrates.
b. pesticide solution.
c. finished sprays.
d. inert carrier.

36. (417) Which formula should you use to determine the number of square feet in a triangle?

a. $X = B^2$.
b. X = B x P x .5.
c. X = W x L.
d. X = W x L x H.

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37. (417) Which formula should you use to determine the number of cubic feet in a room?

a. $X = B^2$.
b. $X = B \times P \times .5$.
c. $X = W \times L$.
d. $X = W \times L \times H$.

38. (418) The formula for calculating the capacity in gallons of a rectangular container is

a. $X = D^2 \times L \times .034$.
b. $X = W \times L^2 \times .0429$.
c. $X = L \times W \times D \times .00434$.
d. $X = L \times D \times W \times .004329$.

39. (419) You are to apply pesticide at the rate of 75 pounds of finished product per acre with equipment that dispenses 3 pounds per minute over a 30-foot swath. Determine the speed at which the equipment must travel to apply the pesticide at the specified rate.

a. 6.6 mile per hour.
b. 3.3 mile per hour.
c. 0.66 mile per hour.
d. 0.066 mile per hour.

40. (420) Pesticides and their solvents are usually prepared on a

a. volume basis.
b. weight basis.
c. PSI basis.
d. PPM basis.

41. (420) How many ounces of 50% malathion emulsifiable concentrate must be added to water to produce 2 gallons of 10% malathion?

a. 5.12 ounces.
b. 25.6 ounces.
c. 51.2 ounces.
d. 76.8 ounces.

42. (420) How many pounds of water-dispersible powder must be added to 100 gallons of water to prepare a 2.5% malathion suspension from 50% wettable powder?

a. 83.4 pounds.
b. 41.7 pounds.
c. 25.4 pounds.
d. 4.17 pounds.

43. (421) How many pounds of total product will be required to treat six acre-feet of water at the rate of 2 ppm?

a. 12.2.
b. 24.1.
c. 32.4.
d. 61.3.

44. (422) Dust particles with a size of about 175 micron are classified as

a. coarse.
b. fine.
c. medium.
d. minute.

45. (422) Dust particles with a size of 44 microns or less are considered

a. fine. c. medium.
b. coarse. d. minute.

46. (422) The effectiveness of a pesticide

a. decreases with an increase of its exposed surface.
b. decreases with a decrease of its exposed surface.
c. increases with a decrease of its exposed surface.
d. increases with an increase of its exposed surface.

47. (423) Select the two kinds of ecosystem elements that exist in the biosphere.

a. Biotic and natural. c. Abiotic and natural.
b. Biotic and abiotic. d. Natural and nitrogen.

48. (423) The basic cycle within the ecosystem is the

a. hydrogen phosporous cycle. c. oxygen cycle.
b. nitrogen cycle. d. carbon cycle.

49. (424) The problem of pesticide drift is greatest during

a. fogging application. c. dusting application.
b. aerial application. d. flooding or raining.

50. (425) Pesticides should be used only when

a. no other technique will do the job.
b. the area is over populated with pests.
c. mechanical devices are not effective.
d. biological methods are not effective.

51. (425) The least desirable technique of corrective controls is

a. legal controls. c. preventive controls.
b. natural controls. d. routine programming.

52. (426) In what two forms does resistance to pesticides occur?

a. Physiological and behaviouristic.
b. Detoxification and absorbtion.
c. Habitat or detoxification.
d. Storage and excretion.

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53. (426) Pesticide poisoning occurs as a result of

a. bio-physical imbalance.
b. blockage of life functions.
c. routine pesticide poisoning.
d. detoxification.

54. (427) Which of the following statements best describes the toxicity of a pesticide?

a. A compound that will cause death or injury in a given situation.
b. A compound that has the ability to cause death or injury.
c. A compound which represents a variable quantity.
d. A compound in which the amount of danger will vary with its location.

55. (427) What does the 50 represent in LD50?

a. The solution is half and half.
b. 50% of the solution is toxic.
c. 50% of a test group is killed by a measured dosage.
d. The toxicity of the pesticide is 50%.

56. (427) What terms are used to express the exposure routes of toxicity?

a. Oral and dermal.
b. Lungs and skin.
c. Mouth and skin.
d. Intravenous and digestive.

57. (428) When you are selecting special equipment to be used for a particular pest management situation, you should refer to the

a. Table of Insects.
b. Table of Allowance.
c. Table of Equipment.
d. Cost vs Life Table.

58. (428) Which of the following factors is most important when selecting pesticide dispersal equipment?

a. Cost.
b. Safeness.
c. Durability.
d. Effectiveness.

59. (429) Which of the following pieces of spray equipment is most widely used by pest managers?

a. Compressed air sprayer.
b. Disposable aerosol dispenser.
c. Refillable aerosol dispenser.
d. Siphon atomizer.

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60. (429) Select the piece of equipment that operates like a siphon atomizer

a. compressed air sprayer. c. paint sprayer.
b. aerosol dispenser. d. pistol sprayer.

61. (430) When neatness and careful placement of insecticidal dust are required, which duster should be used?

a. Hand bellows. c. Hand plunger duster.
b. Hand shaker. d. Rotary hand duster.

62. (430) What type pesticide equipment is best suited for applying pesticide over small outdoor ground areas?

a. Hand shakers. c. Foot pump dusters.
b. Hand bellows. d. Granular spreaders.

63. (431) Which of the following pieces of portable powered equipment is used to disperse only solution formulations to control flying insects in small outdoor areas?

a. Backpack mist-dust blowers.
b. Frame-mounted hydraulic sprayers.
c. Hand-carried thermal fog generators.
d. Hand-carried ultra-low volume generators.

64. (431) Which of the following pieces of portable powered equipment is primarily designed to apply highly concentrated pesticide formulations?

a. Frame-mounted hydraulic sprayers.
b. Backpace mist-dust blowers.
c. Hand-carried thermal fog generators.
d. Hand-carried ultra-low volume generators.

65. (432) Which of the following pieces of nonportable powered equipment is designed to disperse liquid, dust, and granular formulations?

a. Trailer-mounted hydraulic sprayers.
b. Mechanical aerosol generators.
c. Thermal fog generators.
d. Mist-dust blowers.

66. (432) In nonportable thermal fog generators, pesticide is broken into an aerosol by

a. special nozzles. c. air pressure.
b. exhaust gases. d. boom nozzles.

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67. (433) What is a primary requirement for inplace stock and structural fumigation operations?

    a. All openings must be taped.
    b. All pesticides used must be nontoxic to humans.
    c. A liquid-tight cover over the stack or building.
    d. An air-tight cover over the stack or building.

68. (433) What is the purpose of a sand snake in the fumigation process?

    a. To seal the corners of stack or buildings.
    b. To seal the air-tight cover at the floor or ground.
    c. To act as a weight for covers at roof edges.
    d. To act as a weight for door and window ledges.

69. (433) You can be sure that you have applied the proper rate of fumigation to a stack or building by

    a. applying a specified amount of fumigant for a specified time.
    b. checking to see that all pests are dead.
    c. using more than the calculated amount of fumigant.
    d. taking air samples of the area being fumigated.

70. (433) Which of the following fumigants does not require the use of a respiratory protective device while it is being applied?

    a. Aluminum phosphide.
    b. Hydrogen cyanide.
    c. Methyl bromide.
    d. Vapam.

71. (434) Which of the following traps is best suited for crawling pests where the use of pesticides would be unsafe?

    a. Baited jar traps.
    b. Light traps.
    c. Cage traps.
    d. Snap traps.

72. (435) Which of the following frightening devices requires approval of the base commander?

    a. Revolving flashes.
    b. Sound recordings.
    c. Tranquilizing devices.
    d. Firearms.

73. (435) When is aerial spraying most effective?

    a. In cold weather.
    b. In hot weather.
    c. When the wind is blowing briskly.
    d. In the early morning or just before dusk.

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74. (436) Which of the following pumps provides a large volume at a moderate pressure?

a. Rotary gear.
b. Piston.
c. Centrifugal.
d. Diaphragm.

75. (436) Which of the following pumps is suitable for high pressure, stands abrasives well, and is easy and inexpensive to repair?

a. Diaphragm.
b. Piston.
c. Nylon-roller.
d. Rubber-impellar.

76. (437) Which of the following components is the most important part of a sprayer?

a. The pump.
b. The mixer.
c. The pressure regulator.
d. The nozzle.

77. (437) Which of the following types of spray nozzles is best suited for spraying distant targets and crack and crevice treatment?

a. Regular flat fan nozzle.
b. Even flat fan nozzle.
c. Solid stream nozzle.
d. Hollow cone nozzle.

78. (438) What is indicated by the number 9 on a disc nozzle?

a. The output is .9 gal per minute.
b. The output is rated at 90 psi.
c. The spray angle is 90°.
d. The disc has a 9/64 opening.

79. (438) Select the Teejet nozzle you should use to spray an emulsion on an ordinary surface at an angle of 60° with rate of 0.3 gallons per minute at 40 psi.

a. A 3006 nozzle.
b. A 3008 nozzle.
c. A 6003 nozzle.
d. An 8003 nozzle.

80. (439) Which of the following publications outlines equipment maintenance and operating instructions for all the services?

a. TOs.
b. TIMs.
c. TMs.
d. NAV DOCS.

81. (439) What organization usually prepares Standard Operating Procedures and Operational Instructions?

a. The manufacturers.
b. Major Air Command.
c. The operational organization.
d. Air Force Logistics Command.

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82. (440) A preoperation inspection should be performed on your equipment before

    a. every operation.
    b. the first operation of the day.
    c. the first operation of the week.
    d. the first operation in the morning and afternoon.

83. (441) When you are performing a preoperational inspection on a compressed air sprayer, you should

    a. release the air through the shutoff valve on nozzle.
    b. release the air by turning the pump assembly very slowly counterclockwise.
    c. not fill the tank more than half full of liquid.
    d. not pressurize to more than 50 psi.

84. (441) What is the final step in the preoperational inspection of spray equipment?

    a. Place the pressurized tank under water to check for leaks.
    b. Pressurize without liquid to see if it will hold.
    c. Fill with pesticide and start spraying.
    d. Test with plain water.

85. (442) Which of the following precautions is standard for most manual dusters?

    a. Insure proper lubrication and adjustments.
    b. Operate them with the wind at your back.
    c. Use an inert dust for preoperational inspection.
    d. Do not try to carry them by yourself.

86. (443) What is the final step in the operating procedures for the backpack mist-dust blower?

    a. Shut off pesticide before stopping engine to clear chamber.
    b. Shut off fuel to engine to stop it.
    c. Operate the engine at low rpm prior to shutdown.
    d. Use all pesticide in unit before stopping.

87. (443) When you are refueling a handcarried ultra-low volume generator, you should

    a. use only leaded gasoline in the fuel tank.
    b. mix the fuel and oil in the proper proportion and pour it into the tank.
    c. use only unleaded gasoline in the fuel tank.
    d. pour one-half pint of ten weight oil into the fuel tank.

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88. (443) When you are performing a preoperation inspection on an exploder, you should wear

a. a face shield.
b. ear plugs or muffs.
c. a filtering face mask.
d. form fitting protective clothing.

89. (444) Before you start the nonportable mist-dust blower, you should make sure that the boom is

a. removed.
b. pointed upward.
c. pointed downward.
d. in a horizontal position.

90. (445) When the regulator on the trailer-mounted hydraulic sprayer unloads, the excess pesticide goes

a. back to the tank.
b. to the spray nozzles.
c. to the relief drain line.
d. back to the inlet side of the pump.

91. (446) When the delivery rate of the nonportable thermal fog generator is increased, the

a. fuel pressure is increased.
b. fuel pressure is decreased.
c. burner temperature is decreased.
d. burner temperature is increased.

92. (446) Which of the following pesticide solvents is preferred for the nonportable thermal fog generator?

a. No. 2 diesel oil.
b. Fog oil.
c. Kerosene.
d. 10 weight engine oil.

93. (447) A manometer reading of 5.2 inches of mercury is obtained on the mechanical aerosol generated by

a. adjusting the engine choke after warmup.
b. positioning the three way valve.
c. regulating the engine governor control.
d. positioning the flow control valve.

94. (448) If the engine of a nonportable ultra-low volume generator is operating at 2500 rpm and proper pressure cannot be maintained, most likely the

a. engine vacuum is low.
b. drive belt tension is loose.
c. viscosity of pesticide is too high.
d. lines are clogged with pesticide residue.

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95. (449) Which one of the following statements best describes the inspection requirements of manual, powered portable, and powered nonportable dispersing equipment?

    a. An equally thorough inspection is required for each of the three types of equipment.
    b. Portable powered equipment requires the most thorough inspection since the operator is so close to it.
    c. Nonportable powered equipment is more complex and requires a more thorough inspection.
    d. Manual equipment requires the most thorough inspection since it is not as sturdy as others.

96. (450) Which of the following types of maintenance is not considered organizational maintenance?

    a. Equipment repair.
    b. Component replacement.
    c. Equipment overhaul.
    d. Calibration and adjustment of controls.

97. (451) To triple rinse equipment, you should use

    a. two rinses with detergent and water, and one rinse with clear water.
    b. one rinse with detergent and water, and two rinses with clear water.
    c. three separate rinses with detergent and water.
    d. three separate rinses with plain water.

98. (451) Equipment designed for applying dusts and /or granules is best cleaned by

    a. vacuuming.
    b. washing.
    c. flushing.
    d. rinsing.

99. (452) What type of oil is generally used in the engine block of most powered dispersal equipment?

    a. SAE 90W nondetergent.
    b. SAE 30W nondetergent oil.
    c. SAE 30W detergent oil.
    d. SAE 10-40W detergent oil.

100. (454) Entomology shop personnel are not authorized to make which of the following carburetor adjustments?

    a. Governor.
    b. Idle speed.
    c. Fuel/air mixture.
    d. Choke.

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101. (454) Select the component that is normally repaired rather than replaced.

a. Spray guns.
b. Inoperative indicator gage.
c. Damaged shaft bearing.
d. Worn drive belt.

102. When you perform maintenance on spray nozzles to insure the proper output and spray pattern, what kind of maintenance are you performing?

a. Repair.
b. Adjustment.
c. Calibration.
d. Service.

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CDC 56650

ENTOMOLOGY SPECIALIST

(AFSC 56650)

Volume 4

Disease Vectors and Pests of Domestic Animals

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THIS PUBLICATION HAS BEEN REVIEWED AND APPROVED BY COMPETENT PERSONNEL OF THE PREPARING COMMAND IN ACCORDANCE WITH CURRENT DIRECTIVES ON DOCTRINE, POLICY, ESSENTIALITY, PROPRIETY, AND QUALITY.

Preface

IN THIS VOLUME of CDC 56650, *Entomology Specialist*, you will learn about the many arthropods that carry diseases to humans and domestic animals, as well as those generally considered to be pests. Because of the immense numbers of these arthropods, this course can cover only the most important disease vectors and pests.

Arthropods are divided into two classes: Insecta and Arachnida. The insects that this volume will cover include mosquitoes, flies, fleas, and lice. You will also learn about two arachnids: ticks and mites.

As an entomology specialist, you must be extremely knowledgeable of these arthropods because you will be responsible, to a large degree, for protecting base personnel and domestic animals from diseases and morale problems that may be associated with these arthropods.

This volume provides you with information to enable you to identify the medically important insects and arachnids. You will also learn about the life cycles, habits, and habitats of these important arthropods so that you can implement timely control programs. To assist you further in the selection and implementation of effective and safe control programs, this volume outlines the control measures, chemical and nonchemical, that you can use to manage the arthropods that you identify.

Appendixes A and B are included as a separate inclosure to Volumes 4, 5, 6, and 7.

Please note that in this volume we are using the singular pronouns *he, his,* and *him* in the generic sense, not the masculine sense. The word to which these pronouns refer is *person.*

If you have questions on the accuracy or currency of the subject matter of this text, or recommendations for its improvement, send them to Tech Tng Cen/TTGOX, Sheppard AFB TX 76311. NOTE: Do not use the suggestion program to submit corrections for typographical or other errors.

If you have any questions on course enrollment or administration, or any of ECI's instructional aids (Your Key to Career Development, Behavioral Objective Exercises, Volume Review Exercise, and Course Examination), consult your education officer, training officer, or NCO, as appropriate. If he can't answer your questions, send them to ECI, Gunter AFS AL 36118, preferably on ECI Form 17, Student Request for Assistance.

This volume is valued at 30 hours (10 points).

Material in this volume is technically accurate, adequate, and current as of August 1977.

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CHAPTER 1

NOTE: In this volume, the subject matter is developed by a series of Learning Objectives. Each of these carries a 3-digit number and is in boldface type. Each sets a learning goal for you. The text that follows the objective gives you the information you need to reach that goal. The exercises following the information give you a check on your achievement. When you complete them, see if your answers match those in the back of this volume. If your response to an exercise is incorrect, review the objective and its text.

Mosquitoes

MOSQUITOES have probably caused more human disease and suffering than any other group of insects. Such diseases as malaria and yellow fever kill thousands of people each year in certain parts of the world. Mosquitoes are very important in the epidemiology of many diseases. For this reason, the Air Force is vitally interested in the mosquito and its control. After reading this chapter you should know (1) the methods and cycles of disease transmission, (2) the significance and characteristics of important mosquito species, (3) the development and habits of mosquitoes, and (4) the techniques of surveying, collecting, and controlling mosquitoes.

1-1. Disease Transmission Methods and Cycles

Diseases can be transmitted mechanically or biologically by an arthropod. Within these two methods, there are two cycles by which an arthropod can infect humans and animals: the host-parasite cycle and the host-parasite-vector cycle. You need to know about these methods, cycles, and diseases so that you can control the arthropods involved. Mosquitoes are the most important group of arthropods that transmit disease to humans.

600. Complete given statements that concern the cycles in which diseases are transmitted.

Host-Parasite Cycle. The host-parasite cycle of disease transmission involves only two living factors, as illustrated in figure 1-1. The two-factor diseases are transferred from human to human without the assistance of any other living organism.

Some common diseases that are transmitted through the host-parasite cycle are measles, pneumonic plague, cholera, typhoid fever, gonorrhea, and syphillis.

Measles and pneumonic plague can be spread from one human to another by the air, cholera can be contracted from water, and typhoid fever can be contracted from food. Gonorrhea and syphillis are venereal diseases that are contracted through intimate sexual relations.

Certain diseases in which arthropods, such as mites which cause scabies, parasitize man fit the two-factor (host-parasite) epidemiologic pattern. By making a minor adjustment to include arthropods that harm man directly but are not parasites you can add diseases classified under "envenomization" (including spider bites and bee stings) to this cycle. A disease entity similar to the latter group and which may be classified with them is tick paralysis. This condition sometimes follows the prolonged attachment of a hard tick to a region of the neck.

Of all the diseases discussed that are transmitted within the host-parasite cycle, the arthropod-related diseases are the only ones that have a susceptible link that you can control as an Air Force entomology specialist. The other diseases must be controlled by medical service personnel with immunization, innoculation, quarantine, and decontamination programs.

Host-Parasite-Vector Cycle. The host-parasite-vector cycle of disease transmission involves three primary living factors. This disease transmission cycle can be separated into two categories: a human as the

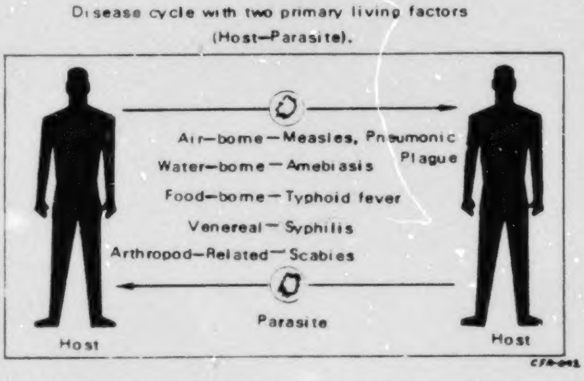
Disease cycle with two primary living factors
(Host—Parasite).
Air—borne—Measles, Pneumonic Plague
Water—borne—Amebiasis
Food—borne—Typhoid fever
Venereal—Syphilis
Arthropod—Related—Scabies
Parasite
Host
Host

Figure 1-1. Disease cycle with two primary living factors (host-parasite).

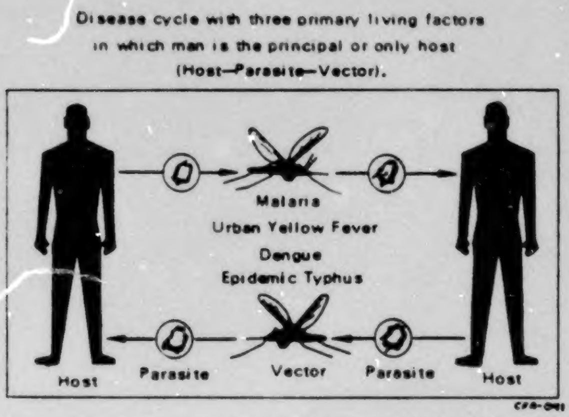
Disease cycle with three primary living factors
in which man is the principal or only host
(Host—Parasite—Vector).
Malaria
Urban Yellow Fever
Dengue
Epidemic Typhus
Host
Parasite
Vector
Parasite
Host
CYA-041

Figure 1-2. Disease cycle with three primary living factors in which man is the principal or only host (host-parasite-vector).

principal or only host and a human as the incidental host.

Diseases involving humans as the principal or only host. These diseases include filariasis, dengue, malaria, yellow fever, dysentery, and epidemic typhus (see fig. 1-2). These diseases are transmitted by, and are often perpetuated in, animate carriers. Although in the broadest sense, vector-borne diseases may include those transmitted from human to human, general usage in the United States restricts the term "vector-borne disease" to those transmitted to humans by arthropods or nonhuman vertebrates.

Dengue and yellow fever are caused by viral parasites transmitted by the *Aedes* mosquitoes. Filariasis is caused by helminth parasites biologically transmitted by the *Culex* mosquitoes. Malaria is caused by protozoan parasites biologically transmitted by the *Anopheles* mosquitoes. Dysentery is caused by bacterial parasites mechanically transmitted by flies. Epidemic typhus is caused by a rickettsial parasite mechanically transmitted by the body louse.

Diseases involving humans as the incidental host. These diseases include rabies, plague, tularemia, spotted fever, murine typhus, and encephalitis (see fig. 1-3). These diseases are transmitted from animals to humans and are usually called zoonoses. In this disease cycle the nonhuman vertebrates arthropods are designated as the vectors and are the normal hosts for the disease while humans and domestic animals are the incidental hosts. The incidental hosts are nonessential and at times are dead ends in this chain of disease transmission.

In this cycle of disease transmission, control programs should be directed toward the vector because in most cases the vector is the most susceptible link in the chain.

Exercises (600):

1. There are ________ basic cycles involved in the transmission of ________ to humans by living ________ .
2. The cycles are identified as the ________ cycle and the ________ cycle.
3. The two-factor diseases are transmitted from ________ to ________ without the assistance of any other ________ .
4. Some common diseases that are transmitted through the host-parasite cycle include ________ , ________ , ________ , ________ , ________ , and ________ .
5. Measles and pneumonic plague can be spread from one human to another by ________ .
6. Cholera can be contracted from ________ .
7. Typhoid fever can be contracted from ________ .
8. Syphillis and gonorrhea are ________ .
9. Arthropods which harm man directly but which are not parasites, cause diseases by ________ and include ________ and ________ .
10. The host-parasite vector cycle of disease transmission involves ________ living factors.
11. Diseases involving humans as the principal or only host include ________ , ________ , ________ , ________ , and ________ .
12. Dengue and yellow fever are caused by ________ which are transmitted by the ________ mosquitoes.
13. Filariasis is caused by ________ parasites which are ________ transmitted by the ________ mosquitoes.
14. Malaria is caused by ________ parasites which are biologically transmitted by the ________ mosquitoes.
15. Dysentery is caused by ________ parasites which are ________ transmitted by ________ .
16. Epidemic typhus is caused by a ________ parasite and is mechanically transmitted by the ________ .
17. Diseases involving humans as the incidental host include ________ , ________ , ________ , ________ , ________ , and ________ .

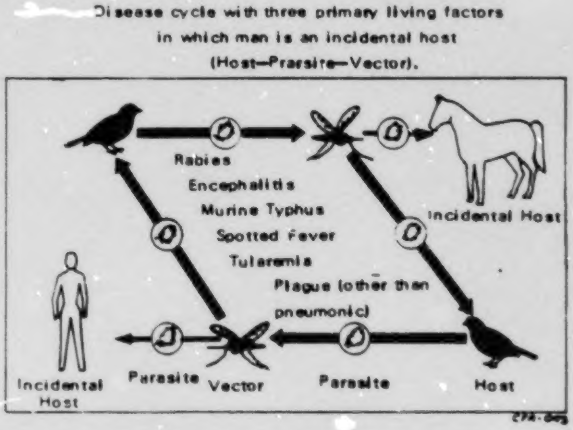
Disease cycle with three primary living factors
in which man is an incidental host
(Host—Prarsite—Vector).
Rabies
Encephalitis
Murine Typhus
Spotted Fever
Tularemia
Plague (other than pneumonic)
Incidental Host
Incidental Host
Parasite
Vector
Parasite
Host
CYA-043

Figure 1-3. Disease cycle with three primary living factors in which man is an incidental host (host-parasite-vector).

18. These diseases are transmitted from __________ to __________ and are usually called __________.

601. Name and explain the two methods for transmitting vector-borne diseases and complete given statements concerning certain diseases and the ways in which they are transmitted.

Mechanical Transmission Methods. Mechanical transmission of disease occurs when an arthropod transports microorganisms, such as dysentery, typhoid, or cholera bacteria, on its feet, body hairs, or other surfaces to human food or to the human.

In mechanical transmission, the parasite neither changes nor multiplies significantly within the vector. The arthropod is simply a vehicle that transports the parasite. Some examples are:

1. Houseflies and cockroaches	- the typhoid fever bacillus is carried on the feet and body hairs, or the bacillus which causes dysentery passes through the alimentary canal with feces or through regurgitation.
2. Tsetse flies	- The protozoan that causes African sleeping sickness is carried on the mouth parts.
3. Stable flies	- The anthrax bacillus is carried on the mouthparts.
4. Deerflies	- The tularemia bacillus is carried on the mouthparts.

The housefly, *Musca domestica,* is probably the most loathsome mechanical transmitter of disease. Throughout much of the world it is a common sight to see flies, which have recently bred or fed in filth, crawling over human food and dishes and even on people's faces. Scientific studies have shown a close relationship between the incidence of bacillary dysentery and the abundance of flies in a community. Flies may also carry the virus of trachoma from one person to another. Cockroaches and vinegar gnats are known to visit sewers and liquid excrement or decaying food and later feed on human food in houses.

Biological Transmission Methods. Biological transmission of disease occurs when the arthropod not only transmits the microorganisms from one host to another host but is essential to the life history of the parasite.

When the parasite multiplies, changes in form, or passes through part of its cycle in the arthropod vector, which serves as an essential host, the transmission is termed "biological." The period of multiplication and change until an infected vector becomes infective is called the extrinsic incubation period, to distinguish it from the period of disease incubation in man, the intrinsic incubation period. There are three basic types of biological transmission.

Propagative. The parsites multiply within the vector but undergo no change in form. Examples are: mosquitoes with encephalitis or yellow fever viruses that multiply in the cells of the gut and the salivary glands, ticks with spotted fever rickettsiae in various tissues, and fleas with plague bacteria in the gut cavity.

Cyclo-developmental. The parasites undergo changes in form within the vector but do not multiply. An example is the filarial worm in a vector mosquito.

Cycle-propagative. The parasites undergo change in form and also multiply within the vector. Examples are malarial parasites in an anopheline mosquito and trypanosomes (which causes Chagas' disease) in a triatomine kissing bug.

There are some unusual types of biological transmission when rickettsial diseases are involved.

Transovarial transmission occurs when a rickettsial disease is passed from the adult female tick or mite to the eggs that are layed.

Transstadial transmission occurs when the rickettsial disease is passed from larva and/or nymph to adult.

Exercises (601):

1. On a separate sheet of paper, name and explain the two methods of transmitting vector-borne diseases.

2. Complete the following statements concerning diseases and the methods of transmission.
   a. The typhoid fever bacillus is carried on the __________ and __________ of __________ and __________.
   b. The protozoan that causes African sleeping sickness is carried on the __________ of __________.
   c. The anthrax bacillus is carried on the ______ of __________.
   d. The housefly is probably the most loathsome __________ transmitter of disease.
   e. Biological transmission of disease occurs when the arthropod not only transmits the microorganisms from one __________ to another but is essential in the life __________ of the parasite.
   f. Transovarial transmission occurs when a __________ disease is passed from the adult female __________ or __________ to the __________ that are laid.
   g. Transstadial transmission occurs when the rickettsial disease is passed from __________ or __________ to __________.

602. Match certain mosquito species with given descriptive statements, and complete other statements concerning the significance of mosquitoes and diseases transmitted.

Mosquitoes and Their Significance. As we said earlier, mosquitoes are the most important group of arthropods that transmit disease to humans. Because numerous species are involved, there are marked differences in their breeding habits, behavior, and dispersal. Three genera are of particular concern as carriers of disease: *Anopheles, Aedes,* and *Culex*. These genera are shown in figure 1-4.

Little was known of the mosquito's role in the transmission of disease until 1877 when it was discovered that a filarial worm was transmitted by a mosquito. The transmittal of the worm was proven in 1897 by a scientist named Sir Roland Ross. In 1900, after years of extensive experimentation, Dr. Carlos Finlay and Walter Reed proved that *Aedes aegypti* was the vector (carrier) of yellow fever.

Malaria. The various types of malaria are acute or chronic diseases caused by tiny protozoan parasites of the genus Plasmodium which are transmitted from person to person by the bite of Anopheles mosquitoes. Although there are 15 Anopheles species in the United States, only two seem to be particularly important in malaria transmission: *Anopheles quadrimaculatus* east of the Rockies, and *Anopheles freeborni* west of the Rockies.

Yellow Fever. This viral disease may be acute and fatal or so mild that infections are not apparent. The two epidemiological types, *urban* and *jungle yellow fever*, are caused by the same virus, and protection is given by the same vaccine, but the mosquito vectors and vertebrate hosts are quite different.

Urban yellow fever. This disease is transmitted by the yellow fever mosquito, *Aedes aegypti*. Although no epidemics have occurred in the United States since the outbreak at New Orleans in 1905 and no major epidemic has occured in the Americas since 1942, epidemics were once reported for most of the large seaports in southern United States, and sometimes as far north as Philadelphia, New York, and Boston. Formerly, this malady recurred over wide areas of South and Central America and was introduced repeatedly into the United States. *Aedes aegypti* has been eradicated from many of the countries in Central and South America. In 1964 the United States began to work on the *Aedes aegypti* Eradication Program in the southern United States, Puerto Rico, and the Virgin Islands, and in 1965 in Hawaii. The program made much progress in these areas until it was curtailed in late 1968 because of lack of funds.

Jungle yellow fever. This disease, also called sylvan or sylvatic yellow fever, is normaly a disease of monkeys and some other wild animals, transmitted most frequently by species of treetop-frequenting *Haemagogus* and *Aedes* and possibly by *Sabethes*. The occasional human cases are contracted when people in the forest are bitten by infected mosquitoes. *Haemagogus spegazzinii falco*, a tree-hole breeder, appears to be the major vector in South America, being replaced by *Aedes leucocelaenus clarki* and other species in Central America and parts of South America.

Dengue. Dengue, also known as breakbone fever, is an acute, rarely fatal disease caused by a virus. It is characterized by sudden onset, high fever, severe headache, backache, joint pain, and a rash appearing the third or fourth day, particularly on the hands and feet.

Dengue fever is transmitted from person to person by the yellow fevere mosquito, *Aedes aegypti*. The cycle, therefore, is similar to that of urban yellow fever. *Aedes albopictus* is an important vector in Hawaii, the Philippines, and Southeast Asia. Mosquitoes obtain the virus from the blood of infected persons during the time period of the day before the initial fever to the third or fourth day of the disease. The virus multiplies in the mosquito, which becomes infective in from 8 to 14 days after the infected blood meal. Under favorable temperature conditions, the mosquitoes remain infective for the rest of their lives, which may be 1 or 2 months or more.

Dengue may occur in epidemic form in almost any part of the Tropics or subtropics. It has been prevalent in the Mediterranean, Africa, South America, Southeast Asia, and the Pacific Islands. The Public Health Service has been concerned with six outbreaks in the past 40 years.

Encephalitis. A number of arthropod-borne viral (arbovirus) diseases affect the central nervous system, causing an encephalitis, or inflammation of the brain (encephalon). Eastern (EE), Western (WE), St. Louis (SLE), California (CE), and Venezuelan equine (VEE) are the types of encephalitis occurring in the United States; each is caused by different viruses.

Human cases of the arthropod-borne encephalitides (plural of encephalitis) vary from mild, inapparent infections to very severe illnesses with permanent damage to the nervous system, or even death. Horses may have similar mild or severe infections with EE, WE, and VEE viruses, whereas the SLE virus causes only inapparent infections. Birds may die from encephalitis, particularly red-winged blackbirds, house sparrows, and pheasants infected with EE virus. The basic transmission cycle from bird to bird is maintained by mosquitoes with the human and horse cases considered as accidents and dead end hosts in the chain of infection.

Small birds and nestlings of such species as the house sparrow, grackle, or red-winged blackbird develop a very high level of virus infection (viremia) for a few days during which time mosquitoes can become infected, whereas the level of virus is usually lower in many of the larger birds, horses, and man.

Eastern encephalitis. This form is one of the most serious arbovirus diseases with 50 to 75 percent of the human cases ending fatally. This disease is found along the Atlantic and gulf coasts and inland in the Mississippi River Valley in limited areas. It occurs

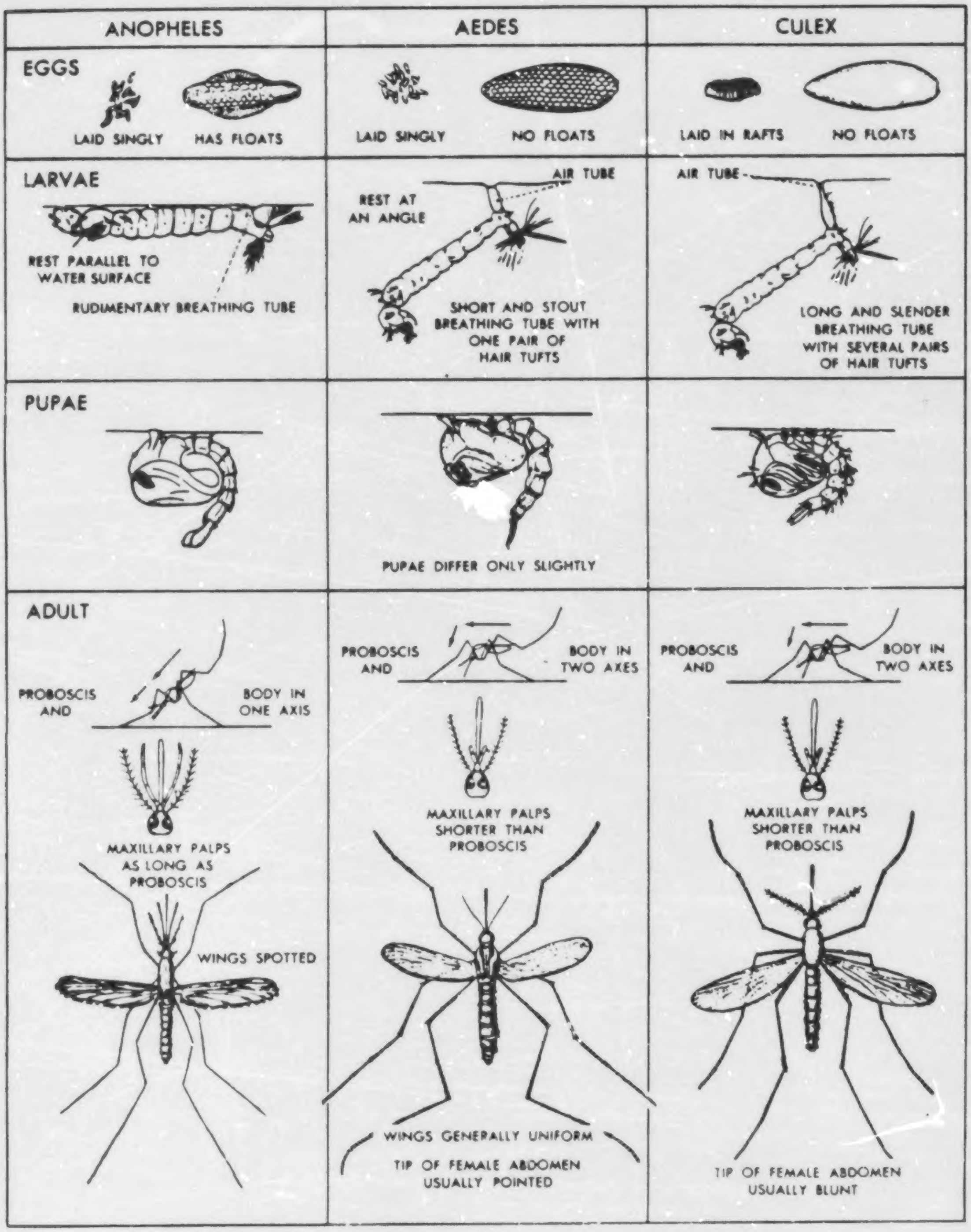
ANOPHELES
AEDES
CULEX
EGGS
LAID SINGLY
HAS FLOATS
LAID SINGLY
NO FLOATS
LAID IN RAFTS
NO FLOATS
LARVAE
REST PARALLEL TO WATER SURFACE
RUDIMENTARY BREATHING TUBE
AIR TUBE
REST AT AN ANGLE
SHORT AND STOUT BREATHING TUBE WITH ONE PAIR OF HAIR TUFTS
AIR TUBE
LONG AND SLENDER BREATHING TUBE WITH SEVERAL PAIRS OF HAIR TUFTS
PUPAE
PUPAE DIFFER ONLY SLIGHTLY
ADULT
PROBOSCIS AND
BODY IN ONE AXIS
MAXILLARY PALPS AS LONG AS PROBOSCIS
WINGS SPOTTED
PROBOSCIS AND
BODY IN TWO AXES
MAXILLARY PALPS SHORTER THAN PROBOSCIS
WINGS GENERALLY UNIFORM
TIP OF FEMALE ABDOMEN USUALLY POINTED
PROBOSCIS AND
BODY IN TWO AXES
MAXILLARY PALPS SHORTER THAN PROBOSCIS
TIP OF FEMALE ABDOMEN USUALLY BLUNT

Figure 1-4 The *Anopheles, Aedes,* and *Culex* Mosquitoes

commonly in horses and in game farm pheasants. *Aedes sollicitans, Aedes vexans,* and *Mansonia perturbans* are suspected vectors of this disease in the bird to human cycle.

Western encephalitis. This disease is found in all of the States west of the Mississippi river as well as in Wisconsin and Illinois. WE virus has been found in limited areas in the eastern United States in birds and mosquitoes. There were many major outbreaks in horses in the 1930's with thousands of cases and many deaths. The largest human epidemic, involving over 3,000 cases, occurred in 1941. Another large epidemic occurred in 1952, particularly in the Central Valley in California. There were 141 reported cases in 1958. More encephalitis was reported in 1965 than at any time since the 1941 epidemic, 172 reported human cases occurring primarily in five States. Western encephalitis is generally a milder disease than Eastern encephalitis, with human deaths reported in 2 to 5 percent of the cases.

Culex tarsalis is the most important mosquito vector of Western encephalitis, particularly west of the Mississippi. Isolations of WE virus have been made from many species of mosquitoes and birds throughout the United States. However, the rarity or absence of *Culex tarsalis* in the eastern United States may help to explain the small number of cases of Western encephalitis east of the Mississippi river.

St. Louis encephalitis. This disease has been found in all of the States west of the Mississippi river, in the Ohio River Valley, in Florida, and in the Camden, N. J.—Philadelphia, Pa., area.

Birds are considered to be the main reservior of St. Louis encephalitis virus, particularly house sparrows, house finches, and domestic pigeons. St. Louis encephalitis is considered to be a more serious disease than Western encephalitis, but less so than Eastern encephalitis. The majority of cases occur in older people. Mortality rates vary from about 5 percent to as high as 33 percent, particularly in people over 60 years of age. Members of the *Culex pipiens-quinquefasciatus* complex are the chief urban vectors. *Culex tarsalis* is the chief vector in rural areas in western States. *Culex nigripalpus* is the vector in the Tampa Bay area, Florida.

St Louis encephalitis is the one type of this disease abundant enough in densely populated areas, as Houston and Dallas, to justify mosquito control as a method of encephalitis control. Cases of the three other types in the United States, Eastern, Western, and California, on the other hand, occur generally in small numbers over wide areas, with lower human populations per square mile, making it difficult to obtain funds to operate effective encephalitis programs by mosquito control.

California encephalitis (CE). This virus was first isolated from *Aedes melanimon* (originally identified as *dorsalis)* and *Culex tarsalis* in California in 1943 and 1944. Most cases of this disease are reported from the Midwestern States, such as Ohio, Indiana, and Wisconsin.

The CE virus differs from Western, Eastern, and St. Louis encephalitis because mammals rather than birds act as reservoirs. This virus or antibodies against the virus have been found in a number of small- and medium-sized mammals, such as snowshoe hares, cottontails, tree squirrels, and ground squirrels. *Aedes triseriatus, Aedes canadensis,* and *Aedes trivittatus* are suspected vectors of this virus since these species are forest- or woodland-dwelling mosquitoes and most of the human cases have occurred in rural, forested areas where the mammal reservoirs live.

Venezuelan encephalitis. This disease occurs often in large epidemics in northern South America and the West Indies. One case was reported in the Miami area in 1968. *Mansonia titillans, Aedes taeniorhynchus,* and *Culex (Melanoconion)* species are suspect vectors.

Filariasis. This disease as occurs in humans is caused by the nematodes, *Wuchereria bancrofti* and *Brugia malayi;* therefore, there are two types of filariasis, the Bancroftian and the Malayan.

These nematodes may live in various parts of the lymphatic system and people may harbor them with no apparent symptoms, or the filarial worms may cause inflammation and other complications. Prolonged or repeated infections may cause extreme enlargement of external genitalia, breasts, or legs in some people and is often referred to elephantiasis.

Filariasis is widespread in many tropical and subtropical regions throughout the world. In the Western Hemisphere it occurs in the West Indies, Colombia, Venezuela, Panama, and the coastal portions of the Guianas and Brazil.

A small endemic center existed for many years near Charleston, S. C., but it has now disappeared. In many parts of the United States, Puerto Ricans and other people who have recently left the Tropics may have the microfilariae circulating in their blood. However, the disease is not now known to be naturally acquired in the United States.

The young filarial worms are transmitted from person to person by various species of mosquitoes. They undergo developmental changes in the mosquito, which is an essential link in the cycle of transmission. The microfilariae occur in the human bloodstream during certain stages of an infection. Here they are picked up by mosquitoes as they feed. A minimum period of 10 to 11 days is required for the developmental stages in the mosquito. From the mosquito they reach the new host at the next feeding. They are not injected into the new host by the mosquito but actively penetrate the skin, perhaps at the site where the mosquito punctured the skin. Many species of mosquitoes are known to be capable of transmitting filariasis, though these may not all be important in nature. Some important known vectors of *W. bancrofti,* are *Culex quinquefasciatus, Culex pipiens, Aedes polynesiensis,* and *Anopheles gambiae.* The generally accepted vectors of *Brugia malayi* are mosquitoes in the genus *Mansonia.*

There have been a few reported cases of human infections with animal filariae. Some of these cases

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may have been caused by the dog heartworm *(Dirofilaria immitis)* of which mosquitoes are known vectors.

Exercises (602):

1. In the blank space by the statements in column A, place the number of the appropriate mosquito species in column B.

Column A

____ a. Carrier of malaria.
____ b. Jungle yellow fever carrier.
____ c. Urban yellow fever carrier.
____ d. Transmits dengue from person to person.
____ e. Vector of Eastern encephalitis.
____ f. Western encephalitis carrier.
____ g. Urban vectors of St. Louis encephalitis.
____ h. Rural vectors of St. Louis encephalitis.
____ i. Suspected vectors of California encephalitis.
____ j. Carry nematodes that cause Bancroftian filariasis.
____ k. Carry nematodes that cause Malayan filariasis.
____ l. Known vectors of animal filariae.
__•__ m. Tampa Bay vector for St. Louis encephalitis.
____ n. Suspected vectors for Venezuelan encephalitis.

Column B

1. *Dirofilaria immitis.*
2. *Culex pipiens quinquefasciatus.*
3. *Aedes melanimon*
4. *Anopheles freeborni*
5. *Aedes aegypti*
6. *Haemagogus*
7. *Sabethes.*
8. *Aedes sollicitans*
9. *Culex tarsalis*
10. *Mansonia titillans*
11. *Aedes polynesiensis.*
12. *Anopheles gambiae*
13. *Haemagogus spegazzinii falco*
14. *Aedes leucocelaenus clarki*
15. *Anopheles quadrimaculatus*
16. *Aedes albopictus*
17. *Aedes vexans*
18. *Mansonia perturbans*
19. *Culex nigripalpus*
20. *Aedes triseriatus*
21. *Aedes canadensis*
22. *Aedes trivittatus*
23. *Aedes taeniorhynchus*
24. *Culex melanoconion*
25. *Mansonia.*

2. Complete the statements below.
   a. The various types of malaria are acute or chronic diseases caused by tiny protozoan parasites of the genus ________ which are transmitted from person to person by the bite of ________ mosquitoes.
   b. Aedes ________ mosquitoes transmit urban ______________ and have been eradicated from many countries of ________ and ______________ .
   c. The cycle of ______________ is similar to that of urban yellow fever.
   d. Human cases of the arthropod-borne encephalitides vary from ________ inapparent infections to ______________ illnesses with ________ damage to the ________ or even ________ .
   e. Eastern encephalitis is one of the most ______ arbovirus diseases with ______ to ______ percent of the human cases ending ______ .
   f. Western encephalitis is found in all of the States west of the ____________ river and in ____________ and Illinois.
   g. Western encephalitis is generally a ________ disease that Eastern encephalitis.
   h. Birds are considered to be the ____________ of the St. Louis encephalitis virus.
   i. The California encephalitis virus differs from the other in that ____________ rather than birds act as ________ .
   j. Filariasis is caused by ________ and is sometimes called ________ .

1-2. Mosquito Development and Habits

In order to control mosquito populations effectively, you need to know how mosquitoes develop from eggs to adults as well as how they behave as adults.

603. Complete given statements concerning the development process of mosquitoes.

Mosquitoes have four distinct stages in their life history: the egg, larva, pupa, and adult (fig. 1-4). The first three stages occur in water, but the adult is an active, flying insect that feeds on the blood of man and animals or upon plant juices.

Eggs. Eggs are white when first deposited but become dark within an hour or two. In general, mosquito eggs fall into three distinct groups: (1) those laid singly on the water surface; (2) those laid together to form rafts which float on the water surface; and (3) those laid singly out of the water. These differences are reflected in the structure of the egg.

Anopheline eggs are laid singly on the water surface. They are elongate oval, usually pointed at one end and provided with a pair of lateral floats (see fig. 1-4). They average about one-half millimeter in length. Hatching usually takes place within 2 or 3 days. The eggs of *Toxorhynchites* are also laid singly on the water surface where they are kept afloat by means of air bubbles that form among the spines on the eggshell.

The eggs of *Culex, Culiseta, Mansonia* and *Uranotaenia* are laid side by side to form a raft often containing 100 or more eggs. They remain afloat on the surface of the water until hatching occurs, usually only a few days.

Eggs that are laid out must be placed so that the larvae can readily reach the water or they must be able to survive long periods of drying until such time as they may be flooded. The eggs of *Aedes aegypti, Aedes triseriatus,* and *Aedes orthopodomyia* are laid on the sides of containers or tree holes just above the water level so that with a rise in the water the eggs hatch. Other species of *Aedes* and all species of *Psorophora* lay their eggs on the ground where they remain until flooding occurs. Some species may survive in the egg stage for 3 to 5 years if flooding does not occur. In some cases hatching occurs as soon as the eggs are flooded; thus, several generations per year may occur. This is typical of the *Psorophora* group and of *Aedes vexans* and *Aedes sollicitans.* Others must be subjected to freezing before they will develop; thus, there is only a single generation per year. Many species of *Aedes* belong in this group, examples being *Aedes stimulans* and *Aedes abserratus*.

Larvae. The larvae of all mosquitoes live in water: in permanent ponds and marshes, in temporary flood waters or woodland pools, in water contained in tree holes, leaves of plants, or artificial containers. Mosquitoes have adapted themselves to almost all kinds of aquatic situations except flowing streams and the open waters of large streams, lakes, and seas. Although mosquito larvae get their food from the water in which they live, they must come to the surface for air or, as in the case of *Mansonia*, obtain air from the underwater portions of plants.

The larval period includes four developmental instars which usually require at least 4 to 10 days for completion. At the end of each instar the larva sheds its skin, or molts. The fourth instar is the mature larva and with the fourth molt the pupa appears.

Mosquito larvae move about in two ways: by jerks of the body and by propulsion with the mouth brushes. Movements of anopheline larvae at the surface are generally of the first type. The "crawling" movements of culicine larvae over the bottom and the slow movement at the water surface are probably due to propulsive action of the mouth brushes. Mosquito larvae assume characteristic positions in the water. Anopheline larvae lie parallel to the surface, while most other groups hang head down with only the tip of the air tube penetrating the surface film. Although larvae are heavier than water, they can rest just beneath the surface without effort. Certain nonwetting structures, such as the air tube in the culicines and the spiracular plate and palmate hairs in the anophelines, serve to suspend them from the surface film.

Many physical, chemical, and biological characteristics of water affect mosquito larvae. These characteristics include temperature, light, movement, dissolved gases and salts, and other living organisms present. Vegetation is important as protection for the larvae. Predators, such as fish and insects, destroy great numbers of mosquito larvae.

The three body regions of the larva, head, thorax, and abdomen, are distinct. The head bears the antennae, eyes, and mouthparts. The antennae are located on each side toward the front. Behind the antenna near the hind margin of the head are the eyes. The mouthparts are at the underside of the head near the front. They consist of a series of brushes in addition to the grinding and grasping structures. Thus, the larvae is able to strain out small aquatic organisms and particles of plant and animal material present in the water. A few predaceous species have mouthparts adapted for grasping and swallowing their prey.

The thorax is broader than the head or abdomen and is somewhat flattened. It has several groups of hairs which are useful in identification of species.

The abdomen is long and subcylindrical, consisting of nine well-defined segments. The first seven segments are similar, but the eighth and ninth are considerably modified. The eighth segment bears the respiratory apparatus. In the anophelines this apparatus consists of paired spiracular openings, while in the other groups a prominent air tube is present. The ninth segment is out of line with the other segments and bears two to four membranous tapering appendages commonly known as anal gills. These anal gills seem to serve more for the regulation of osmotic pressure than for respiration.

Pupae. The mosquito pupa also lives in water and is very active. It does not feed, but it must come to the surface for air except in the case of *Mansonia* species (spp). The pupa differs greatly from the larva in shape and appearance, the front part, consisting of the head and thorax, being greatly enlarged and enclosed in sheath. On the upper surface is a pair of respiratory trumpets. The abdomen consists of eight freely movable segments with a pair of paddles at the tip.

Mosquito pupae are undoubtedly the most active of all insect pupae. Most species are lighter than water, their buoyance being due to an air space between the wing cases on the underside of the combined head and thorax. By vigorous movement of the abdomen, the pupae move about with considerable speed, rising directly to the surface when movement stops.

The pupal stage lasts from 1 day to a few weeks, no species being known to pass the winter as pupae. At the end of the pupal stage, the pupal skin is broken and the adult works its way out, crawls onto the surface of the water, and is soon ready to fly away.

Adult. The adult mosquito (fig. 1-5) is a small fragile insect with a slender abdomen, one pair of narrow wings, and three pairs of long, slender legs. It varies in length from slightly over 1/16 inch to about 1/2 inch. The three body regions, head, thorax, and abdomen, are well defined.

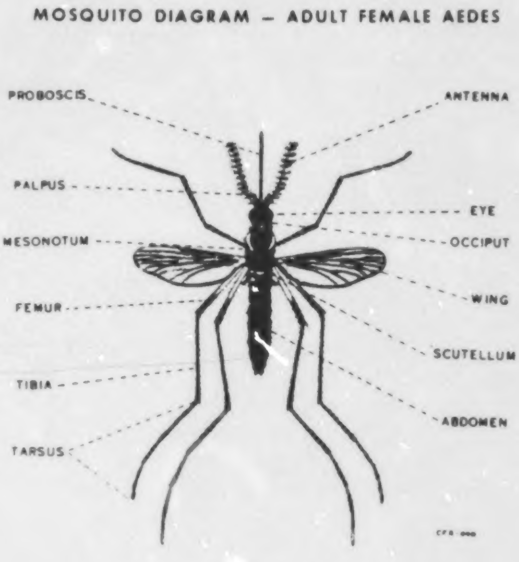

Figure 1-5 Mosquito diagram — adult female mosquito

The head of a mosquito (fig. 1-5) is almost spherical and is joined to he thorax by a narrow membranous connection. It bears a pair of large compound *eyes*, a pair of *antennae*, a pair of *palpi* and the *proboscis*. The antennae arise on the front of the head between the eyes. They are long, slender structures consisting of 15 segments, only 14 of which are ordinarily visible. Each of the last segments bears a whorl of hairs which are short and sparse in the females but long and bushy in the males. The antennae are believed to serve as organs of hearing and smell. The palpi are five-segmented structures originating at the lower front margin of the head near the proboscis. In anophelines, the palpi of the female are about as long as the proboscis, while those of the male are enlarged at the tip. In culicines the palpi of the females are short, while those of the male are usually long, densely haired, and pointed. The proboscis projects downward and forward from the lower front margin of the head. It consists of a labium or sheathlike structure enclosing a group of six stylets. The labium serves as a protective sheath for the stylets but does not enter the wound when the mosquito is biting. The stylets serve to penetrate the skin of the host animal and also form a small duct through which saliva is injected into the wound, as well as a canal through which liquid food is drawn. The mouthparts of the male are incapable of piercing the skin of human or animal hosts.

The thorax or middle region of the body, bears the wings and legs. The upper surface of the thorax or *mesonotum* is covered with coarse hairs or scales and bears several groups of hairs or bristles used for identification purposes. The long, slender legs arise from the lower sides of the thorax. Each leg consists of a short conical *coxa*, a small hinge-like *trochanter*, a stout *femur*, a long slender *tibia*, and a five-segmented *tarsus*. The first segment of the tarsus is the longest and is often equal to the tibia in length. The fifth tarsal segment bears a pair of small claws. The legs are covered with scales of varying colors, forming patterns which are often useful in separation of species. The wings are long and narrow with characteristic venation. The veins are clothed with scales, often of varying colors which may be distributed to form definite patterns. The hind margin of the wing also bears a close-set row of long, slender, fringe scales. A pair of small knobbed structures known as *halteres* is found behind and slightly below the wings. They vibrate rapidly when the mosquito is in flight and serve as organs of equilibrium.

The elongate abdomen (fig. 1-5) is nearly cylindrical consisting of 10 segments, only 8 of which are readily visible. The 9th and 10th segments are greatly modified for sexual functions. North American species of *Anopheles* have no scales on the upper surface of the abdomen. In the cullicines, the abdomen is covered with scales which often form characteristic markings. In *Aedes* and *Psorophora*, the female abdomen is tapered apically, with the eighth segment withdrawn into the seventh. In other genera in the United States the abdomen is bluntly rounded at the apex. The terminal segments of the male abdomen are greatly modified for mating. These structures are often of value in identification of the species.

Exercises (603):

1. Mosquitoes have __________ distinct stages in their life history; the __________, __________, __________, and __________.
2. Anopheline eggs are laid __________ on the __________ surface.
3. Eggs which are laid out of the water must be placed so the larvae can __________.
4. Some species may survive in the egg stage for __________ to __________ years if __________ __________.
5. The eggs of some species must be subjected to __________ before they will develop.
6. The larvae of all mosquitoes live in __________.
7. Mosquitoes have adapted themselves to almost all kinds of aquatic situations except __________ and __________.
8. Water characteristics that affect mosquito larvae are __________, __________, __________, __________, and other __________.
9. Mosquito larvae have three distinct body regions: the __________, __________, and __________.
10. The head bears the __________, __________, and __________.
11. The thorax is broader than the __________ or __________ and is somewhat __________.
12. The abdomen is long and subcylindrical, consisting of __________ well-defined __________.
13. The mosquito pupa lives __________ and is __________.
14. The pupal stage lasts from __________ to a __________.
15. The adult mosquito is a __________, __________, insect with a slender __________, one pair of narrow __________ and three pairs of __________ __________.
16. The head of a mosquito is almost __________ and is joined to the thorax by a narrow __________ connection.
17. The thorax, or middle region of the body, bears the __________ and __________.

604. Given statements concerning the general habits of adult mosquitoes, identify and correct any false statements.

General Habits of Adult Mosquitoes. About equal numbers of male and female mosquitoes are produced. The males ordinarily emerge first and remain near the breeding places, mating with the females soon after their emergence. Only the females bite and most (but not all) species require a blood meal before they can lay fertile eggs. The female tends to travel greater distances and appears to live longer than the male.

Flight habits vary considerably. *Aedes aegypti*, probably the most domesticated of all mosquitoes, breeds primarily in and around human habitations and flies short distances, usually a "block" or about 100 yards. Most anophelines have a maximum flight range of about 1 mile. However, other species, such as *Aedes vexans* and *Aedes sollicitans* can fly 10 to 20 miles or more.

Mosquitoes also vary considerably as to their preferred hosts, some species feeding on cattle, horses, or other domestic animals, while others prefer man. A few species feed only on cold-blooded animals and some subsist entirely on nectar or plant juices. Some are active during the daytime and others only at night.

The female mosquito requires 2 days or more to digest the blood meal she has ingested, lay a batch of eggs, and then seek another blood meal. This cycle of feeding, laying eggs, and feeding again may be repeated four or five times or more in the time between the first blood meal and the later one (10 to 14 days afterward) when the mosquito is infective and can pass on parasites which have developed in her body.

The lifespan of adult mosquitoes is not well known. Some species apparently live 1 or 2 months during the summer, although under unfavorable conditions this time may be greatly reduced. Adults that hibernate may live for 6 months or more.

Exercises (604):

Place a C by correct statements and an I by incorrect statements; explain why incorrect statements are false.

____ 1. There are more female than male mosquitoes.

____ 2. Males ordinarily emerge first.

____ 3. Males usually leave the breeding places soon after emergence.

____ 4. Males mate with females soon after emergence.

____ 5. Only females bite.

____ 6. All species require a blood meal before they can lay fertile eggs.

____ 7. Flight habits vary considerably and distances range from several feet to as much as 20 miles.

____ 8. Mosquitoes show no preference as to their host.

____ 9. The female mosquito requires 2 days or more to digest a blood meal, lay a batch of eggs, and seek another blood meal.

____ 10. Hibernating mosquitoes may live as long as 6 months or more.

1-3. Important Mosquito Species

As you probably know by now, the four most important genera of mosquitoes are the *Aedes*, *Anopheles*, *Mansonia* and *Culex*. You need to know as much as you can about the species in these genera so that you can control them for medical or nuisance reasons. You also should be familiar with these and other mosquitoes that are pests to domestic animals.

605. Match important Aedes mosquito species with their identifying characteristics.

Important Aedes Mosquitoes. The genus *Aedes* contains more than 500 species distributed from the polar regions to the Tropics. Almost half of all North American mosquitoes belong to this genus, which includes many of the major pest species as well as important disease vectors. There are some 60 species of *Aedes* known from the United States of which about 40 may be rather common, at least in certain regions. In general the *Aedes* mosquitoes assume greater importance as one goes from the Tropics northward. In the northern United States, as well as in Canada and Alaska, many species of *Aedes* occur and are often present in astronomical numbers. Appendix B has been included in the supplement to this volume for you to refer to during the following discussion.

Aedes aegypti. This mosquito is known as the yellow fever mosquito. It is a small, dark species that you can recognize by the lyre-shaped silvery-white lines on the thorax and by the white bands on the tarsal segments. It is the vector of urban yellow fever and dengue. It is a pest of some significance when it occurs in large numbers.

This species has a limited distribution within the United States. It occurs in the Southeastern and Southern States, extending northward to North Carolina, Tennessee, and Arkansas.

Aedes aegypti is semidomesticated, breeding almost exclusively in artificial containers in and around human habitations. The eggs are laid singly on the sides of the container at or above the waterline, or, less commonly, on the water surface. They are able to withstand drying for several months and hatch quickly when the container is again filled with water. Hatching may take place in 2 or 3 days if temperatures are high. Typical breeding places are flower vases, tin cans, jars, discarded automobile tires, unused water closets, cisterns, rain barrels, and sagging roof gutters. *Aedes aegypti* breed also in tree holes, their traditional breeding site. Under favorable conditions the larvae complete their development in about 6 to 10 days, or in much longer periods in cool weather. The pupal period is about 2 days under normal conditions. The life cycle may be completed in 10 days, although it may vary up to 3 weeks or more. It breeds throughout the year in the Tropics with generations succeeding each other rapidly. In the southern United States, the reproduction rate slows down during the winter, and the eggs may remain dormant for several weeks or months. This species is very susceptible to cold and does not survive the winter except in the southern United States.

The adults apparently prefer the blood of humans to that of other animals, entering houses readily, often those that are well screened. *Aedes aegypti* bites principally during the morning and late afternoon. It attacks quietly, preferring to bite about the ankles, under coat sleeves, or at the back of the neck, often becoming a troublesome pest. The adults appear to be rather long lived as they live 4 months or more in the laboratory. Their flight range is normally about 100 feet to 100 yards, but long distances have been recorded.

Aedes canadensis. This dark mosquito has the tarsi banded with white at both ends of the segments. It is widely distributed in the United States, being particularly common in the Northern States. It is often a serious pest in woodland situations but rarely migrates far from its breeding places. California encephalitis has been found in this species.

Aedes canadensis is one of the first mosquitoes to appear in early spring. The larvae breed in woodland pools filled with melting snows or by spring rains. This kind of mosquito shows preference for pools with a bottom of dead and decaying leaves, although it may also be found in roadside puddles, sink holes, wooded swamps and isolated oxbows of small woodland streams. There may be more than one generation per year and the adults live for several months.

Aedes dorsalis. This mosquito is medium sized and varies in color from dark brown to a whitish straw color. The upper surface of the abdomen is marked with a longitudinal stripe of pale scales and the hind tarsi are banded with yellowish scales at both ends of the segments. *Aedes dorsalis* is a severe pest of humans and cattle throughout the arid and semiarid regions of western United States. It occurs over most of the country, but it rare and unimportant in the Eastern and Southern States. *Aedes melanimon* is very similar to *dorsalis* (from which California encephalitis was first isolated) in the West.

The larvae develop in the salt marshes of the Pacific Coast and in irrigation and flood waters of the interior. It is a common breeder in irrigated pastures and waste water pools. Several broods are produced each year in irrigated areas, a brood following each flooding.

The females of *Aedes dorsalis* are vicious biters. They attack day or night, being particularly active in the evening or on calm, cloudy days. They are strong fliers and occasionally migrate in large broods. They are commonly found 10 miles from their breeding places; a flight of 22 miles has been recorded in Utah. The females, and at times, the males, may be taken in great numbers in light traps. Overwintering takes place in the egg stage, moreover the eggs may remain viable for several years.

Aedes sollicitans. The salt-marsh mosquito *Aedes sollicitans* is the most important of the salt-marsh species and one of the most severe mosquito pests known. It occurs along the Atlantic and Gulf Coastal Plains from Maine to Texas and has been reported from many inland areas where brackish waters are available. Such inland records include New York, Indiana, Kentucky, Illinois, Oklahoma, Arkansas, and New Mexico. Adults can be recognized by the golden color of the upper side of the thorax and a longitudinal stripe of white or yellowish-white scales on the abdomen. The proboscis and tarsi also have wide pale bands. The eggs of this species are laid on the mud of marshes where they remain until flooded by high tides or rains. Breeding generally occurs on the parts of the marsh not covered by daily tides; usually pot holes and depressions of various sizes are used, but sometimes they occur over extensive level areas. The eggs must remain dry for at least 24 hours before they will hatch. After having been dry for a week or two, they hatch within a few minutes when covered with water. Development of the larval and pupal stages requires seven to ten days during warm weather. Several generations can be produced each year.

The adults of *Aedes sollicitans* are strong fliers and often migrate in large swarms from the marshes to cities and towns many miles away. They very commonly fly 5 to 10 miles and may travel up to 40 miles or more. The migratory flights begin just before dark and may consist of tremendous numbers of mosquitoes. During the day they rest among the grasses, though they will readily attack anyone who disturbs them, even in full sunlight. They are fierce biters and may literally drive a person from the marsh areas. Fortunately, they do not often come indoors. They have been a very severe deterrent to the development of some of the coastal resort areas. They are often collected in light traps in great numbers.

Aedes taeniorhynchus. The black salt-marsh mosquito has crossbands of white scales on the upper side of the abdomen and white rings on the proboscis and tarsi. It occurs on the coastal plains from Massachusetts to Texas and on the Pacific coast in southern California. It has also been reported from certain inland areas around salt pools in oil fields. It is the most abundant and troublesome salt-marsh species along the South Florida coasts and may be a severe pest as far north as New Jersey.

The breeding habits are similar to those of *Aedes sollicitans*, though it also breeds in fresh water pools near the salt marshes. The adults are strong fliers and fierce biters. They are active principally at night and are suspected vectors of California encephalitis. They may be very annoying in the shade during the day, but are less likely than *Aedes sollicitans* to attack in bright sunlight. The flight range for most females is approximately 4 miles.

Aedes triseriatus. The tree-hole mosquito is blue-black in appearance with silvery-white scales at the sides of the thorax. It occurs throughout most of eastern United States. It breeds principally in tree holes, old tires, tin cases, barrels and other artificial containers. Because the bite is painful, this species can be troublesome in the woods. It is suspected of carrying California encephalitis. Adults apparently do not wander far from their breeding places. Larval development is rather slow as nearly a month is required to reach maturity.

Aedes trivittatus. This species is widely distributed in northern United States from Maine to Idaho. It has been taken as far south as Georgia, Louisiana, and Arizona. It is a fierce biter and an extremely annoying pest in some of the Northern States. It is a suspected vector of California encephalitis. The upper surface of the thorax is marked with two conspicuous whitish stripes.

The larvae occur mostly in flood-water pools and temporary rain pools. The yound larvae feed at the surface of the water, but the later instars spend most of their time concealed in the vegetation at the bottom of the pool. Perhaps it is for this reason that larvae are seldom encountered even though adults may be present in large numbers. Emergence of adults begins about 8 days after hatching. The adults rest among grasses and other vegetation during the daytime. They will bite when disturbed, but are especially active in the evening. They apparently do not migrate far.

Exercises (605):

Match the Aedes mosquito species in column B with applicable characteristics in column A. Place the letter of the species in the blank space by the characteristic. Some characteristics may apply to more than one species.

A - Characteristics

____ 1. Small and dark with lyre-shaped silvery-white lines on the thorax.
____ 2. The tarsi is banded with white at both ends of the segments.
____ 3. Medium-sized mosquito varying from dark brown to whitish straw color.
____ 4. Very similar to dorsalis.
____ 5. Most important of the salt-marsh species.

B - Species

a. *Aegypti*
b. *Taeniorhynchus*
c. *Sollicitans*
d. *Trivittatus*
e. *Triseriatus*
f. *Dorsalis*
g. *Canadensis*
h. *Malanimon*

____ 6. Found on the coastal plains from Massachusetts to Texas.
____ 7. Tree-hole mosquito.
____ 8. Fierce bites and an extremely annoying pest.
____ 9. Strong fliers and migrate in large swarms.
____ 10. Prefers the blood of humans to that of other animals.
____ 11. Principally active at night.
____ 12. Suspected vector of California encephalitis.
____ 13. Vector of urban yellow fever.
____ 14. Severe pest of humans and cattle throughout the arid and semi-arid regions of the western United States.
____ 15. One of the first mosquitoes to appear in the early spring.
____ 16. Eggs must dry for at least 24 hours before they will hatch.
____ 17. Widely distributed in northern United States from Maine to Idaho.

606. Complete given statements concerning important Anopheles mosquitoes.

Important Anopheles Mosquitoes. Anopheline mosquitoes are distributed throughout the United States, one or more species being present in every state. Most anophelines have spotted wings while most culicines have clear wings. The females are easily distinguished from the culicines by having palpi about the same length as the proboscis. Anophelines can usually be distinguished also by their resting position. The anophelines rest with the head, thorax, and abdomen in a straight line normally at an angle of from 40° to 90° while the culicines rest nearly parallel to the surface.

Appedix B is included in a separate supplement for your reference while important mosquito species are being described.

Anopheles quadrimaculatus. This fairly large, dark-brown mosquito has four dark spots near the center of each wing. The palpi and tarsi are entirely dark.

This species is the most important vector of malaria in the United States. It is the anopheline most frequently found in houses, and is more likely to attack humans than any other anopheline of the United States, with the possible exception of *Anopheles freeborni.* Careful studies have shown that approximately 5 percent of the meals are human blood. *Anopheles quadrimaculatus* has probably been responsible for the transmission of almost all human malaria which has occurred east of the Rocky Mountains. The bites are less painful than those of many other species of mosquitoes and often go unnoticed.

This species is distributed from the southeastern United States northward to southern Quebec and Ontario and westward to the Dakotas, central Nebraska, Kansas, Oklahoma, and Texas. It also occurs in eastern Mexico as far south as Vera Cruz. It has been of greatest importance in the South Atlantic and Gulf Coastal Plains and the lower Mississippi River Valley. It may also become abundant at times in areas as far north as Minnesota, Michigan, New York, and New England.

Anopheles quadrimaculatus breeds chiefly in permanent fresh-water pools, ponds, and swamps that contain aquatic vegetation or floating debris. It is most abundant in shallow waters. In some areas it appears to favor open, sunlit waters while in others it is found in densely shaded swamps. This species shows a preference for clear, quiet waters neutral to alkaline (it does not usually occur where the pH is lower than six).

Anopheles quadrimaculatus larvae can withstand rather low temperatures, but they do not complete their development at temperatures below 50 to 55° F. (10.08 to 12.88 C.) and no appreciable development takes place until the water temperature reaches 65 to 70° F. (18.48 C.). Even at these temperatures, from 30 to 35 days may be required for development of the aquatic stages. The most favorable temperature for the development of *Anopheles quadrimaculatus* is between 85 to 90° F. (29.68 to 32.48 C.) at which only about 8 to 14 days are required. Larvae may often be found where water surface temperature exceeds 100° F. during the afternoon, although they probably cannot survive constant water temperatures much above 95° F. (35.28 C.).

The males emerge first, remaining near the breeding places. The females mate soon after emergence, often during their first day, either before or after the first blood meal. A female may mate repeatedly, although one mating is sufficient to insure the production of fertile eggs during her entire life. Egg laying begins from 2 to 3 days after the first blood meal. A single female may lay as many as 12 batches of eggs and a total of over 3000 eggs.

During the daytime adults remain inactive, rest in cool, damp, dark shelters, such as buildings, caves, and under bridges. Feeding and other activity occurs almost entirely at night. They enter houses readily to feed upon humans but they feed more frequently on other warm-blooded animals, such as cows, horses, mules, pigs, and chickens. Normally most adults fly not more than one-half mile from their breeding place and only a small percentage fly farther than 1 mile. *Anopheles quadrimaculatus* is not ordinarily taken in light traps in great numbers.

In the most southern part of the country, *Anopheles quadrimaculatus* breeds continuously through the year. Over most of its range, however, it spends the winters as fertilized adult females in caves, hollow trees, basements, and other protected places. In all but the most northern areas it may emerge from hibernation and move about and take blood meals on warm days during the winter. In the spring, the females emerge, take a blood meal and deposit their eggs. There may be as many as 9 or 10 generations each season. Populations often reach a peak during July or August and decline rapidly in September and October. Hibernating females may survive for 4 to 5 months.

Anopheles freeborni. The western malaria mosquito is similar in appearance to *Anopheles quadrimaculatus.* It is the most important vector of malaria in western United States. It enters homes and animal shelters readily and bites avidly at dusk and at dawn. This species occurs over most of the area west of the Continental Divide, from southern British Columbia to Lower California and may occur eastward to West Texas.

Anopheles freeborni breeds in permanent or semipermanent waters at least partially exposed to the sunlight with vegetation or flotage. Clear, clean, slightly alkaline water is preferred. Larvae may also be found in slightly brackish water near the ocean or in desert pools. It normally avoids water polluted with sewage or other organic materials. Breeding may take place in habitats very similar to those in which *Anopheles quadrimaculatus* is found, but it has for the most part adapted itself to seepage areas, borrow pits, hoof prints, improperly irrigated fields, and the edges of streams and irrigation canals. Rice fields are a particularly favorable breeding place for this species. This mosquito is well adapted to the semiarid region in which it occurs.

In California, *Anopheles freeborni* leave their hibernating places [illegible] February, obain a blood meal, and lay eggs for the first generation. Because of the abundance of breeding places at this time of year and the scarcity of predators, large broods develop. Succeeding generations are greatly reduced in range and size by the recession of waters, except where irrigation waters maintain their breeding places. In late fall at the end of the dry season, females migrate long distances, sometimes 10 to 12 miles to seek shelter in outbuildings, homes, and cellars. During the winter season they are in a state of semihibernation from which they emerge on warm days and nights for feeding. The winter biting is sometimes referred to as "nibbling." They move about nervously, often attacking at the ankles and seldom feeding to repletion. These winter feedings usually do not result in development of eggs. They may, however, result in the transmission of malaria.

The midseason flight range of *Anopheles freeborni* is generally restricted to a 1-mile radius. In cases of very heavy production in rice fields, longer flights up to 2½ miles have been noted. Males are seldom found more than one-quarter mile from their breeding places.

Exercises (606):

1. The *Anopheles quadrimaculatus* is the most important vector of ____________ in the United States.
2. The *quadrimaculatus* is the species most frequently found in ____________ , and is more likely to attack ____________ .
3. Approximately ____________ percent of the *quadrimaculatus* meals are ________________ .

4. The *quadrimaculatus* bite is __________ painful than other species and will often go __________.
5. The *Anopheles freeborni* is the most important vector of __________ in the western United States.
6. Rice fields are particularly favorable __________ for the *freeborni*.
7. The *freeborni* enters homes and animal shelters and bites avidly at __________ and at __________.
8. The *freeborni* normally avoids water polluted with __________ or other __________ materials.
9. In California, freeborni leave their hibernating places in __________.
10. In late fall, at the end of the dry season, *freeborni* __________ migrate long distances.
11. Winter feedings by *freeborni* usually do not result in development of __________ ; however, __________ may be transmitted.
12. Male *freeborni* are seldom found more than __________ from their breeding places.

607. Indicate whether given statements concerning Culex mosquitoes are correct or incorrect.

Important Culex Mosquitoes. The genus *Culex* includes about 300 species. Most of these species occur in the tropical and subtropical regions of the world. Although some 26 species have been reported in the United States, only 12 of these are at all common. The group includes several important pest species and disease vectors.

Refer to Appendix B in the supplement while you are studying these important mosquito species.

Culex pipiens and Culex quinquefasciatus. The northern and southern house mosquitoes are closely related and difficult to separate. They are medium-sized, brown mosquitoes with crossbands of white scales on the abdominal segments but no other prominent markings. *Culex pipiens,* the northern house mosquito, occurs throughout the northern United States and extends as far south as Georgia and Oklahoma. *Culex pipiens quinquefasciatus,* the southern house mosquito, occurs in all the Southern States from coast to coast and extends northward to Nebraska, Iowa, Illinois, and Ohio. One or both of these mosquito species are found in every State.

The house mosquitoes are the most common species in many of our urban communities and rural premises. They often enter houses where their habit of "singing" is very annoying. *Culex quinquefasciatus* is a severe pest. *Culex pipiens* may also feed on man. Members of the *Culex pipiens quinquefasciatus* complex are important vectors in urban epidemics of St. Louis encephalitis, particularly in the Midwest.

Culex pipiens and *Culex quinquefasciatus* breed prolifically in rain barrels, tanks, tin cans, and practically all types of artificial containers. Other important sources of these mosquitoes are storm-sewer catch basins, poorly drained street gutters, polluted ground pools, cesspools, open septic tanks, and effluent drains from sewage disposal plants. A heavy production of house mosquitoes is often associated with unsanitary conditions.

These mosquitoes lay their eggs in clusters of from 50 to 400 eggs. The clusters, known as egg rafts, float on the surface of the water. The eggs hatch within a day or two in warm weather. From 8 to 10 days are required for completion of the larval and pupal stages. In somewhat cooler weather or early spring or late fall these aquatic stages may require 2 weeks or more. Breeding continues throughout the warmer months of the year. Some can survive and produce fertile eggs without a blood meal.

These species do not migrate far except when great numbers are being produced. Ordinarily, when adults are present, larvae will be found nearby. They are active only at night and may be found resting during the day in and around houses, chicken houses, outbuildings, and various shelters near their breeding places. They are readily attracted to light traps.

Culex tarsalis. This mosquito is a medium-sized, dark species with a broad, white band at the middle of the proboscis and white bands at each end of the tarsal segments. It is a fairly important pest species in some parts of its range. It is more active soon after dusk and may enter buildings in search of blood. *Culex tarsalis* has been found naturally infected with the virus of both St. Louis and Western encephalitis. Laboratory experiments have also demonstrated its ability to transmit both diseases. Epidemiological studies carried on in several Western States indicate that is it more frequently infected with these viruses than are other mosquitoes. The infection is apparently acquired from feeding upon birds and later transmitting it to other birds or to horses or humans. It is considered to be one of the most, or possibly the most important vector of encephalitis to humans or horses in the western states.

Culex tarsalis is widely distributed west of the Mississippi River including southern Canada and northern Mexico. It is also known from Wisconsin and is most abundant along the Pacific coast. In California, it occurs from sea level up to 7600 feet in the Sierra Nevada. It is essentially a rural mosquito.

The larvae develop in a wide variety of aquatic situations. In the arid and semiarid regions, they use almost all types of water, but they are most frequently found in temporary to semipermanent bodies of water associated with irrigation. These areas include canals, ditches, borrow pits, impoundments, ground pools, and hoof prints. They breed in water flowing from cesspools and other waters containing large quantities of organic material from human wastes. They also breed in artificial containers of various types, such as cans, jars, barrels, drinking troughs, ornamental ponds, and catch basins. Females deposit at least two rafts of eggs, usually containing from 100 to 150 eggs each. Hatching normally occurs within 48 hours. The larval and pupal stages develop rapidly and breeding continues from early spring until late fall.

Adults are active chiefly from dusk to dawn. During daylight hours the adults remain at rest in secluded spots. They frequently can be found on porches, on shaded sides of buildings, in privies, or under bridges. The majority, however, rest in grass and shrubs, or along cut banks of streams. *Culex tarsalis* apparently must have a blood meal in order to produce fertile eggs. It has a wide range of hosts but shows some preference for birds, though it also commonly feeds on cows, horses, and humans. Dispersion studies have shown that *Culex tarsalis* will fly at least 11 miles, although the majority probably remain within a mile of their breeding places. Considerable numbers of *Culex tarsalis* may be collected in light traps and carbon dioxide traps.

Culex nigripalpus. This mosquito is principally tropical, but it occurs as far north as Tennessee and North Carolina. It is quite common in Florida and becomes an important pest species in flooded fields. Larvae are also found in ditches and grassy pools. *Culex nigripalpus* is the proven vector of St. Louis encephalitis virus in the Tampa Bay outbreak in 1962.

Exercises (607):

Identify the following statements as correct (C) or incorrect (I); correct the false statements.

____ 1. The genus *Culex* includes about 300 species found in the tropical and subtropical regions of the world.

____ 2. The northern and southern house mosquitoes are closely related and difficult to separate.

____ 3. Members of the *Culex pipiens quinquefaciatus* complex are important vectors in urban epidemics of Western encephalitis.

____ 4. A heavy production of house msoquitoes is often associated with unsanitary conditions.

____ 5. *Culex* mosquitoes lay their eggs 10 at a time.

____ 6. Eight to 10 days are required for hatching eggs in warm weather.

____ 7. A blood meal is required for fertile eggs.

____ 8. *Culex tarsalis* has been found naturally infected with St. Louis and Western encephalitis.

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____ 9. *Tarsilis* larvae develop in all kinds of water except in waters containing large amounts of organic material.

____ 10. *Tarsalis* apparently requires a blood meal in order to produce fertile eggs.

____ 11. *Tarsalis* has wide variety of hosts but excludes birds.

____ 12. *Culex nigripalpus* is the proven vector of St. Louis encephalitis virus.

608. Complete given statements that pertain to the characteristics of important Mansonia mosquitoes.

Important Mansonia Mosquitoes. This group includes three species in the United States, one of which is very widespread and common. They are troublesome biters and severe pests in many areas. *Mansonia* eggs are laid in rafts on marshes or lakes. After hatching, the larvae descend below the surface of the water and insert their air tubes into the stems or roots of aquatic plants. They remain below the water surface throughout the larval and pupal stages obtaining air from these plants. Because of this unique habit, *Mansonia* larvae cannot be controlled by use of ordinary surface larvicides.

Mansonia perturbans. This mosquito is large, speckled, and brown and white with a characteristic pale band at about the outer third of the hind femur and tibia. It is distributed in the Southern and Eastern States from the gulf coast to Canada. It is also known from some of the Great Plains and Rocky Mountain States and from the four Pacific Coast States. This species has been found naturally infected with the virus of eastern encephalitis in Georgia. Its role in the epidemiology of this has not been established.

Mansonia perturbans breed in marshes, ponds, and lakes having a thick growth of aquatic vegetation. Larval development is unusually slow, requiring several months. The larvae that hatch one season do not ordinarily complete their development until the following spring. They remain below the water surface

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throughout this period though they may detach from their host plants and move about. The pupae also have breathing tubes adapted for penetrating plant tissues and they too attach to plants from which they get their air. The pupal stage requires 5 to 6 days. The adults emerge in late spring or early summer. There appears to be only one generation per year throughout most of the range of this species. It is possible that a partial second brood may be produced in Florida. Larvae have been found associated with a number of plants. Some of the more important ones are pickerel weed, cattail, water lettuce, arrowhead, aquatic sedges, and swamp loosestrife.

The females will bite during the daytime in shady, humid places, but are principally active in the evening and early part of the night. They readily enter houses and bite viciously. These strong fliers are frequently taken in light trap collections.

Mansonia titillans. This tropical species is fairly common in Florida and has also been reported from South Texas. It has been found in nature infected with Venezuelan equine encephalitis virus. The adults are severe biters and fairly important pests in Florida. The eggs of *Mansonia titillans* are laid on the under surface of the leaves of water lettuce. The larvae and pupae attach to the roots of this plant, developing in the same manner as described for *Mansonia perturbans.* The adults are frequently taken in light traps.

Exercises (608):

1. *Mansonia* mosquitoes include ____________ species in the United States.
2. They are troublesome ___________ and severe __________ in many areas.
3. They remain below the water surface throughout the ___________ and ____________ stages.
4. *Mansonia* larvae cannot be controlled by the use of ordinary ___________ larvicides.
5. *Mansonia perturbans* have been found naturally infected with the ____________ of ____________.
6. *Perturbans* larval development is unusually slow, requiring ______________________ .
7. Larvae which hatch one season do not ordinarily complete their development until ______________.
8. The female *perturbans* will bite during the daytime in shady, humid places but are principally active in the ___________ and ______________.
9. These strong fliers are frequently taken in ______________________ .
10. *Mansonia titillians* is a ___________ species fairly common in ____________ and has also been reported from ______________________ .
11. *Mansonia titillians* has been found in nature infected with ______________________ virus.
12. The eggs are laid on the under surface of the leaves of ____________________ .

609. Match listed mosquito species important to domestic animals with the appropriate characteristics.

Mosquitoes Important to Domestic Animals. Almost all mosquito species will attack domestic animals, such as horses, cows, and dogs from time to time, but most are not considered to be serious pests of these animals. However, there are a few species that actually prefer these animals and are serious medical or nuisance pests.

The *Aedes atlanticus, Aedes tormentor,* and *Aedes infirmatus* are almost identical in appearance and can be separated only in the larval stage or by a study of the male genitalia. They are distributed throughout the Southeastern States. The females are vicious biters attacking readily during the daytime in or near wooded areas. They have been reported driving cattle from woodlands by their attacks. The virus of California encephalitis has been isolated repeatedly from this group of mosquitoes.

The *Aedes spencerii* is an important pest mosquito of the prairie regions of Minnesota, North Dakota, Montana, northward into Canada, and southward to Illinois, Iowa, Nebraska, Colorado, and Utah. The females are fierce biters, attacking during the day, even in bright sunlight. They are serious pests of man and livestock. They often migrate into cities and towns, but the extent of their flight range has not been determined. There is probably only one generation a year. The larvae are found in surface pools filled by melting snow or spring rains.

The *Aedes nigromaculis* is a medium-sized, dark mosquito that has a longitudinal line of yellowish-white scales on the upper surface of the abdomen. It has bands of white scales at the base of the tarsi segments but not at the apex. This species is an important pest mosquito throughout the western plains extending from Minnesota west to Washington and south to Texas and Mexico. During recent years it has assumed great prominence in the irrigated pastures of the West, especially in the Central Valley of California. The remarkable spread of this species is indicated by the fact that it was not known in California until 1937. It now occurs over most of the State at the lower elevations and is rapidly replacing *Aedes dorsalis* in open sunlit pools of waste irrigation and other intermittent water.

This species has proved to be extremely well adapted to pasture irrigation. The eggs will hatch within 2 to 6 days after they are deposited, if flooding occurs. *Aedes nigromaculis* is able to produce a brood following each irrigation, which is usually at intervals of 8 to 12 days in the Central Valley of California. Under favorable conditions, a brood may be produced within 5 days, and as many as 20 broods can be produced in one season. In most areas of the San Joaquin Valley, *Aedes nigromaculis* is now the number one pest problem and is present in astronomical numbers. For example, a light trap operating for three nights near an irrigated pasture collected almost a gallon of mosquitoes, predominantly *Aedes nigromaculis.* As many as 20 milion eggs of this species may be found in a single acre of irrigated pasture.

The adult is a severe pest of man and animals, attacking readily and inflicting a painful bit. It will bite during the daytime but is most active during the evening hours. It is a strong flier and may migrate several miles from its breeding ground. This species passes the winter in the egg stage.

The *Culiseta incidens* is the most common culicine mosquito with spotted wings in the United States. It is principally western in distribution, being reported from Texas, Oklahoma, Nebraska, and all States to the west. In some areas, it is a troublesome pest while in others it seems timid about biting man. It is reported as feeding more frequently on domestic animals. *Culiseta incidens* breeds in a wide variety of habitats from the brackish water pools on the Pacific coast to spring water and snow pools in the mountains. It has also been taken in reservoirs, ornamental ponds, hoof prints, rain barrels, and discarded automobile tires.

The *Culiseta inornata* is a large, grayish-brown mosquito with broad, lightly scaled wings. It has been reported from almost all the States except in upper New England. In the Northern and Western States it breeds throughout the spring and summer, while in the South it is more common during the winter. They do not readily attack man, but they do attack domesticated animals and may be of considerable annoyance to livestock. *Culiseta inornata* has been found naturally infected with the virus of Western encephalitis and in laboratory experiments it has been shown capable of transmitting the virus. Its habits indicate that is is unlikely to be an important vector of this disease to man.

The *Psorophora confinnis* is known as the glades mosquito in Florida and the dark rice field mosquito in Arkansas and adjacent rice-producing areas. It is a medium to large dark species having a narrow ring of white scales near the apex of the hind femur. *Psorophora confinnis* is the most widespread and important species of *Psorophora* in the United States. It occurs throughout southern United States, extending westward to South California and northward to Nebraska and Iowa, New York, and Massachusetts. It reaches its greatest abundance in the Florida Everglades and in the rice fields of Arkansas and Mississippi. The females are fierce biters, attacking anytime during the day or night. Great numbers of these mosquitoes may occasionally kill livestock and can make it almost unbearable for humans to remain in infested outdoor areas.

Psorophora confinnis breeds in temporary rain pools, irrigation waters, and seepage pools. Eggs are not laid on water surfaces but on ground that is subject to flooding from rainfall, overflow, or irrigation. Soil with low, rank vegetation seems to be ideal for egg deposition. Drained rice fields are among the most favorable sites. Eggs will hatch after 4 or 5 days if they are submerged at that time. If they remain on the surface of the soil for two or three weeks or longer and are then flooded, hatching may begin within a few minutes. *Psorophora confinnis* passes the winter in the egg stage. The larval period for *Psorophora confinnis* is very short. During midsummer in Arkansas, it may be completed in as little as 4 days. The average time at a mean temperature of 79° F. (26.32 C.) is slightly over 5 days. The pupal stage is completed in 1 or 2 days. The number of generations per season varies from one to many, depending upon how often suitable hatching conditions occur. Areas that dry up and are then flooded a few days later may produce a brood with each flooding. Such conditions are provided with certain types of irigation, particularly rice culture. Adults live from 1 to 2 months. They have a flight range of up to 10 miles.

The *Psorophora ciliata* is a very large, yellowish-brown mosquito with shaggy legs, which is commonly known as the gallinipper. It is a vicious biter and because of its large size presents a terrifying appearance. *Psorophora ciliata* is widespread through eastern United States from Mexico to Canada, being abundant locally in the South and Middle West. When present in numbers it is a severe pest, attacking readily during the daytime as well as in the evening.

It is one of the few species whose larvae feed on other aquatic insects including mosquito larvae. It breeds in temporary pools, often in association with *Psorophora confinnis* and *Aedes vexans* upon which it feeds. The fourth instar larvae may consume three or four other larvae in 1 day. *Psorophora cilita* larvae are easily recognized in the field as they are two or more times as long as most other species. They hang almost straight down from the water surface. The larval and pupal life is short as is characteristic of this group of mosquitoes. The eggs are laid on the surface of drying soil and hatch when flooded as with *Psorophora confinnis.*

Exercises (609):

Match each mosquito species in column B with the appropriate statements in column A pertaining to its characteristics. Place the letter of the appropriate species in the blank spaces by the characteristics.

	A - Characteristics	*B - Species*
____	1. Are almost identical and can be separated only in larval stage or by study of the male genitalia.	a. *Aedes nigromaculis*
____	2. Larvae found in pools filled with melting snow or spring rains.	b. *Psorophora confinnis*
____	3. Was unknown in California until 1937.	c. *Aedes spencerii*
____	4. Known as the glades mosquito in Florida.	d. *Psorophora ciliata*
____	5. Commonly known as the gallinipper.	e. *Culiseta incidens*
____	6. Cause considerable annoyance to livestock but do not normally attack man.	f. *Aedes atlanticus, tormentor, infirmatus*
		g. *Culiseta inornata*

____ 7. In some areas it is a troublesome pest while in other areas it seems timid about biting man.

____ 8. One of the few species whose larvae feeds on other aquatic insects including mosquito larvae.

____ 9. Have been reported driving cattle from woodlands by their attacks.

____ 10. Most widespread and important species of *psorophora* in the United States.

____ 11. As many as 20 broods may be produced in one season.

____ 12. The females are fierce biters, attacking during the day or even in the bright sunlight.

____ 13. Found to be naturally infected with Western encephalitis.

1-4. Mosquito Surveys and Control Methods

Adult and larval mosquito surveys are essential for any effective mosquito control program. Because the larval stage of development is the most susceptible to control, you should direct your efforts toward this stage whenever you can. However, there will be times when you must control adult mosquitoes by mechanical and chemical means. The adult survey will help you know when such a control program is necessary.

610. Complete given statements concerning the purpose for conducting mosquito surveys, and match listed mosquito species with the appropriate collection method used to gather the various species.

Surveys are essential for the planning, operation, and evaluation of any effective mosquito control program, whether for the prevention of mosquito-borne diseases or the lowering of populations of these biting insects to a level permitting normal activities without undue discomfort.

Purpose of Conducting Adult Mosquito Survey. The adult survey permits evaluation of the incidence of mosquitoes in a community where they may bite people, and shows the relative abundance of the various species present at any time. Using this information and reference material on the breeding sites and habits of mosquito species, the vector control specialist can determine the need for a control program and conduct an effective search for the larval breeding places. The adult mosquito survey furnishes data for using space spraying equipment at the best time and place, and for reporting to supervisor and to the public the extent of the problem and results of control operations. Interpreting adult mosquito survey reports and translating this information to action will save manpower, materials, and equipment and furnish justification for the entire operation.

Equipment. The required equipment is simple and inexpensive. It consists of a collecting tube or aspirator, pill boxes, cages (for live collections), field record forms or notebook, pencil, flashlight, and map.

Collection Methods. The methods you use to collect mosquitoes depend upon the species to be collected as mosquito species vary greatly in habits.

Biting collections. The collection of mosquitoes as they bite is a convenient method of sampling populations. In making biting collections or counts, you should expose part of your body by rolling up your sleeves or trouser legs or by removing your shirt. Sit quietly for a designated period of time (usually 10 or 15 minutes). The mosquitoes are collected with an aspirator or chloroform tube, either by the collector or a coworker. In many parts of the Tropics it is customary to make biting collections about sundown from a domestic animal, such as a white horse. If you take collections at night, you need a flashlight. Whether you take counts from human beings or animals, you should remember that certain individuals are more attractive to mosquitoes than others. It is therefore desirable for the same person or animal to be used throughout a given survey. Collections must be made at regular intervals and at approximately the same time of day so that biting rates at different stations may be compared to show trends in mosquito populations.

With day-biting species, the index may be based upon the number of mosquitoes that alight upon one's clothing in a given time interval (the landing rate), rather than those actually in biting position. This method is more practical when populations are very high and is useful for a rapid check of mosquito abundance before and after treatment. The landing-rate method has been used especially with certain species of *Aedes* or *Psorophora* found in salt marshes, rice fields, or the arctic and subarctic tundras.

Bait traps. Animal bait traps, or stable traps have been used extensively in the West Indies, South America, and other parts of the world. Bait traps are somewhat expensive to build, transport, and maintain, but a series of these traps will collect live mosquitoes over a wide areas for a whole night without large numbers of other insects and in areas where electric power is not available. The animal is generally placed in the trap in the evening and left overnight. The trap is inspected early in the morning and the mosquitoes are counted and/or collected. Horses, calves, mules, donkeys, and sheep have been used as attractants.

Window traps. Window traps employing the same principle as the animal bait trap are somtimes used; the humans sleeping inside serve as bait animals. The baffles can be mounted in the windows of the buildings with the screen cages inside to catch mosquitoes as they enter. On malaria control programs the cages usually are placed outside because mosquitoes that have rested on pesticide treated surfaces often have a positive phototropic reaction and try to fly out of a treated house.

Carbon dioxide traps. Solidified carbon dioxide (dry ice) will attract large numbers of some mosquito species. This type of trap is generally baited with about 3 pounds of dry ice and wrapped in newspaper. It is very effective in collecting large numbers of *Culex tarsalis.*

Insect nets. Insect nets are used to collect mosquitoes from grass and other vegetation. This type of collection is of value in determining the abundance of those species that rest in these habitats during the daytime, such as *Aedes vexans, Aedes sollicitans, Aedes taeniorhynchus,* and *Aedes nigromaculis.*

Daytime resting stations. Adults of many species are inactive during the day, resting quietly in dark, cool, humid places. Careful inspection of daytime shelters gives an index to the population density of these mosquitoes. This method is especially useful for anopheline mosquitoes and is commonly used for *Anopheles quadrimaculatus* and *Anopheles freeborni.* It is also of value in estimating populations of some culicines, such as *Culex quinquefasciatus, Culex tarsalis,* and *Culiseta melanura.* Mosquito resting stations may be divided into two general types: natural and artificial.

Natural resting stations are places normally present in an area, such as houses, stables, chickenhouses, privies, culverts, bridges, caves, hollow trees, and overhanging banks along streams. With experience you can evaluate the suitability of shelters by casual inspection. Dwellings, especially when unscreened, often prove to be satisfactory resting stations, being especially important when mosquito-borne diseases are investigated. Under such conditions they furnish an index to the number of mosquitoes which may bite man and transmit encephalitis or other diseases.

Suitable resting stations may not be available in sufficient numbers to give a satisfactory evaluation of the mosquito population. It may be necessary to construct special shelters or to use boxes, barrels, kegs, etc., as artificial resting stations. Many different types of artificial shelters have been used. They should always be placed near the suspected breeding places in shaded, humid locations. Mosquitoes enter such shelters at dawn, probably in response to changes in light intensity and humidity and ordinarily do not leave until dusk.

Light traps. Mosquito light traps attract adults from a considerable area when they are placed in locations remote from competing light sources.

The mosquito light trap is mounted on a post, or hung from a tree, with the light 5½ to 6 feet above the ground. It should be located 30 or more feet from buildings in open areas near trees and shrubs. It should not be placed near other lights, in areas open to strong winds, or near industrial plants giving off smoke or gas. The traps are operated on a regular schedule from one to seven nights per week. They are turned on just before dark and turned off after daylight. You can use an automatic time clock or photoelectric cell to start and stop the trap, or you can turn the trap on and off by hand. The collection should be removed each morning and placed in a properly labeled box until it can be sorted and identified.

Wide differences have been noted in the reactions of different species of mosquitoes to light. Therefore, light trap collections must be used in conjunction with other methods of sampling mosquito populations. They have proven very useful in measuring densities of some mosquitoes, such as *Aedes sollicitans, Aedes vexans, Aedes nigromaculitis, Culex pipiens, Mansonia perturbans.* Some anophelines especially *Anopheles albimanus, Anopheles crucians, Anopheles atropos,* and *Anopheles walkeri,* are also readily taken in light traps. The common mosquito, *Anopheles quadrimaculatus,* however, is seldom taken in significant numbers.

Exercises (610):

1. Complete the following statements concerning the conduct of mosquito surveys by filling in the blanks with the appropriate words.
   a. Surveys are essential for the ________, ________, and ________ of any effective mosquito control program.
   b. The adult survey permits evaluation of ________ ________ mosquitoes in a community where they may bite people.
   c. Interpreting adult mosquito survey reports and translating this information to action will save ________, ________, and ________ and will furnish ________ for the entire operation.
   d. The required equipment is ________ and ________.
   e. The collection of mosquitoes as they bite is a convenient method of sampling ________.
   f. In many parts of the Tropics it is customary to make biting collections about sundown from a ________.
   g. It is desirable for the same person or animal to be used ________.
   h. Collections must be made at ________ intervals and at approximately the same ________ ________.
   i. Animal bait traps have been used extensively in the ________, ________, and other parts of the world.
   j. Window traps are used with ________ serving as bait animals.
   k. Carbon dioxide traps are effective in collecting ________ mosquitoes.
   l. Insect nets are used for collecting mosquitoes from ________ and other ________.
   m. Natural resting places are places ________ present in an area.
   n. Mosquitoes usually enter shelters at ________, probably in response to changes in ________ and ________.
   o. Light traps attract adults from a considerable area when they are placed in locations remote from ________.

p. Wide variations have been noted in the reactions of different species of mosquitoes to ________.

2. Match mosquito species in column B, with the appropriate collection methods in column A. Place a number of the species in the blank space by the collection method.

A - Collection Method	*B - Species*
____ a. Carbon dioxide traps.	1. *Aedes sollicitans*
____ b. Window traps	2. *Psorophora*
____ c. Bait traps	3. *Culex tarsalis*
____ d. Insect nets	4. *Aedes taeniorhynchus*
____ e. Light traps	5. *Anopheles freeborni*
____ f. Resting stations	6. *Aedes nigromaculis*
____ g. Biting collections	7. *Aedes vexans*
____ h. Landing rate	8. *Anopheles quadrimaculatus*
____ i. Day biting collections	9. *Culiseta melanura*
	10. *Culex quinquefasciatus*
	11. *Culex pipiens*
	12. *Mansonia perturbans*
	13. *Anopheles albimanus*
	14. *Anopheles walkeri*
	15. *Anopheles crucians*
	16. *Anopheles atropos*

611. Complete given statements concerning the purpose for conducting larval mosquito surveys and the equipment required; match statements concerning collection methods with the appropriate mosquito species collected.

Conducting Larval Mosquito Surveys. Mosquito larvae are found in all types of aquatic habitats from warm, brackish, seaside marshes to the pure, cold water of melted snows. They are found in such diverse locations as rivers, lakes and ponds, crab holes, pitcher plants, eave troughs, funerary urns, bottles, cans, reservoirs, tree holes, old tires, and vases.

You must assume that mosquitoes have adapted themselves to almost every conceivable type of aquatic situation. You must have information regarding the general breeding habits of the species known or suspected to be present in the area before you begin larval surveys. An experience person may be able to spot the probable mosquito breeding places in a specific areas by means of a rapid reconnaissance survey. These places should be carefully numbered and marked on the map.

Purpose. Larval surveys are required to determine the specific breeding sites and establish permanent larval sampling stations. Larval surveys show the exact areas in which mosquitoes breed and their relative abundance. For this reason they are of special value in control operations.

Equipment. A white enamel dipper about 4 inches in diameter is most used for collecting mosquito larvae. You can extend the handle of such a dipper to a convenient length by inserting a suitable piece of cane or wood. Many special dippers are used for specific purposes so that their capacity can be related directly to the water surface area examined. Thus, you can compute the number of larvae per square foot or square meter with reasonable accuracy.

To inspect small artificial containers or cisterns you may need a flashlight or a mirror to reflect light into the breeding place. You can use large bulb pipettes or siphons made of rubber tubing to remove water from small obscure areas, such as tree holes. The water may then be put in a dipper or pan where the larvae are counted and collected. Widemouthed pipettes (eye droppers) are used for removing larvae from the dipper or pan; small vials, preferably with screwcaps, serve to hold the larvae until they can be identified or mounted on slides. Screened-bottom spoons may be substituted for pipettes if the larvae are to be transferred to widemouthed bottles. Alcohol of 95 percent strength is a most satisfactory preservative but 70 percent alcohol is in common use.

Collection methods. Mosquito larvae are usually found where surface vegetation or debris are present. Thus, in the larger pond or lakes, larvae are ordinarily confined to the marginal areas. It is necessary to proceed slowly and carefully in searching for mosquito larvae, as disturbance of the water or casting of shadows may cause the larvae to dive to the bottom. Anopheline larvae are collected by a skimming movement of the dipper with one side pressed just below the surface. The stroke is ended just before the dipper is full since larvae will be lost if the dipper is filled to the point that it runs over. Where clumps of erect vegetation are present, it is best to press the dipper into such clumps with one edge depressed so that the water flows from the vegetation into the dipper. Culicine larvae, such as *Aedes vexans, sollicitans,* or *taeniorhynchus* or the species of *Psorophora,* require a quicker motion of the dipper because they are more likely to dive below the surface when disturbed.

You should always record the number of dips made and the number of larvae found. The larvae are transferred to small vials by a wide-mouthed pipette and preserved in alcohol for later identification. It is possible to get a rough idea of the breeding rates by computing the number of larvae of each species per dip. The number of dips required depends upon the size of the area, but for convenience they should be made in multiples of ten. Inspections should be made at intervals of 1 to 2 weeks during the breeding season because areas entirely negative at one time may be found breeding heavily at other times.

Variations in the procedure described above are required when inspecting for certain species. For example, *Mansonia* larvae remain below the water surface throughout their development. You can find these larvae by pulling up aquatic plants (cattail, sedges, pickerelweed, etc.) and washing them in a pan of water. A search of the bottom muck and trash from the area where the host plants have been uprooted may be productive. Scoop this material and examine it in pans of clear water.

Inspection for *Aedes aegypti* involves a careful search for artificial containers in which these domestic mosquitoes breed. Such inspections are usually made on a premises-by-premises basis where bottles, tin cans, vases, automobile tires, and all other containers of water are examined. You can find the *Aedes aegypti* index by dividing the total number of premises inspected into the number in which breeding is found. Collection of the larvae may require a dipper but is more frequently accomplished directly by means of a widemouthed pipette.

Inspection for *Aedes triseriatus* and *Aedes sierrensis* involves searching for tree holes and artificial containers in which these species breed. These are often too small to admit an ordinary dipper, but water may be siphoned into a dipper or pan where you can see the larvae.

Exercises (611):

1. Complete the following statements concerning the conduct of mosquito larval surveys.
   - a. Mosquito larvae are found in all types of ________________ .
   - b. Larval surveys are required to determine the specific ________________ and establish permanent larval ________________ .
   - c. Special dippers are used to determine the number of ________________ .
   - d. Screen-bottom ____________ may be substituted for ____________ if the larvae are to be transferred to ________________ bottles.
   - e. Alcohol of ____________ percent is the most satisfactory preservative but ____________ percent alcohol is in common use.
   - f. When collecting culicine larvae, disturbing the surface or casting a shadow will cause the larvae to ________________ .
   - g. You should always record the number of ________ made and the number of ____________ found.
   - h. Inspections should be made at intervals of ________ to ________ weeks.
   - i. Variations in procedures are required when inspecting for ________________ .

2. Match the mosquito species in column B with the collection methods in column A.

A - Collection Methods	*B - Species*
____ a. Skimming with dipper	1. *Aedes aegypti*
____ b. Pulling up aquatic plants and washing in a pan of water	2. *Psorophora*
____ c. Scooping up muck and washing in clear water.	3. *Mansonia*
____ d. Inspecting artificial containers.	4. *Aedes vexans*
____ e. Searching tree holes.	5. *Aedes triseriatus*
	6. *Anopheline*
	7. *Aedes sollicitans*
	8. *Aedes sierrensis*
	9. *Aedes taeniorhynchus*

612. Complete given statements pertaining to methods used in controlling mosquito larvae.

Biological Control. Mosquito-eating fish offer the greatest opportunities in biological control for the average nonresearch mosquito control organization. Many mosquito abatement districts raise and distribute top minnows (such as *Gambusia)* and other small fish to control mosquitoes in cisterns, water tanks, garden pools, and marshes.

In Hawaii and the South Pacific, not-too-successful control has been attempted using the larvae of *Toxorhynchites* (formerly *Megarhinus)* to devour the larvae of *Aedes aegypti* and *Aedes albopictus.* In Canada and Alaska careful observations have been made of the predaceous larvae of *Chaoborus, Mochlonyx,* and *Eucorethra* in the biological control of *Aedes* larvae.

Other possibilities of biological control methods include the use of parasites and bacteria, although these methods have not proven to be effective or practical at this time. The planting of trees in certain locations to shade bodies of water where light-requiring mosquito larvae abound shows good prospects.

Construction and Maintenance Control. The filling of mosquito breeding places with soil, rock, or rubbish is the most permanent kind of mosquito control operations, being of particular value in the elimination of small depressions that do not require a good deal of material. Filling operations often add value to the property.

Mosquito control may be accomplished by open ditching, subsoil drainage, and diking with use of tide gates. The choice of these methods depends upon many factors, such as relative cost, terrain, soil type, and extent of mosquito breeding areas.

Sanitation Control. The method used in controlling mosquito larvae involves the removal of vegetation from impounded water and the removal of all artificial water containers, such as cans, bottles, and tires.

Chemical Control. If areas cannot be drained or filled at reasonable cost and control by fish, salinification, or other naturalistic methods are not possible, larvicidal control is often the method of choice. Larvicidal control is of primary importance in areas where immediate control of pest or disease-carrying mosquitoes is necessary, particularly in cases of extensive flooding following such natural disasters as hurricanes or prolonged rainy seasons.

The synthetic organic insecticides may be applied as dust, pellets or granular formulations, wettable powders, solutions, emulsions or technical grade material. *Dusts* have been widely used as mosquito larvicides, but they are light, subject to air currents and spotty application, and may stick to leaves. *Pellets* or *granular formulations* have a larger particle size permitting them to slip through leaves or dense vegetation reaching the water surface to kill mosquito larvae. *Wettable powders* are frequently used in the prehatch treatment of areas for the control of mosquito larvae. These wettable powders may be applied on snow and ice or on earth in dried-up mosquito breeding areas seeded with eggs of temporary pool mosquitoes. *Oil solutions* may be sprayed on water surfaces to kill both anopheline and culicine larvae and pupae, particularly in waters with high organic content. Most mosquito control organizations continue to use some petroleum oil to kill mosquito larvae that are resistant to the organic insecticides. *Emulsions* have been employed extensively in treating irrigated waters, such as rice fields, where oil solutions would be toxic to cultivated plants. The water in the emulsion serves as a carrier for the minute oil droplets containing insecticides, facilitating treatment of large areas with hydraulic equipment. The emulsion breaks almost immediately after the spraying operation, producing an oil film upon the surface of the breeding area. *Technical grade insecticides* are used particularly with the ULV (ultra low volume) method of control, often from airplanes.

Petroleum oils were the first of the larvicides to be widely used, following the pioneer research of L. O. Howard in 1892, on the use of kerosene to kill mosquito larvae. Petroleum oils are toxic to the eggs, larvae and pupae of both anopheline and culicine mosquitoes. There are two lethal fractions in petroleum oils used for mosquito control: a toxic fraction, with low boiling range and high volatility, which penetrates the tracheae of larvae and pupae and produces an anesthetic effect; and a lasting fraction which acts much slower and generally does not have any direct toxic action but suffocates by mechanical interference with breathing.

NOTE: It is recommended that the larvicide be a different chemical from that used for adult control. For example, it may be desirable to use Paris green or fuel oil with a spreading agent as a larvicide, and malathion as an adulticide. Prior to implementing any type of control program, insure that the program is one that has been approved by appropriate agencies.

Exercises (612):

1. Mosquito-eating ______ offer the greatest opportunities in the biological control of mosquitoes.
2. Many mosquito abatement districts distribute top minnows and other small fish to control mosquitoes in ______ , ______ , ______ , and ______ .
3. In Hawaii and the South Pacific, control has been attempted using the larvae of *Toxorhynchites* to devour the larvae of ______ .
4. The planting of trees to shade bodies of water where ______ larvae abound shows good prospects.
5. Filling of mosquito breeding places is the most ______ of mosquito ______ operations.
6. Sanitation control involves the ______ of ______ from impounded water.
7. Larvicidal control involves the use of ______ in the control of larvae.
8. A disadvantage of dust larvicide is that it is subject to ______ and may stick to ______ .
9. Wettable ______ are frequently used in the ______ treatment of areas for the control of ______ .
10. Oil solutions may be sprayed on water surfaces to kill both ______ and ______ larvae and ______ .
11. Emulsions have been used extensively in treating ______ .
12. Technical grade insecticides are used particularly with the ______ method of control.
13. Petroleum oils are toxic to the ______ , ______ , and ______ of both anopheline and culicine mosquitoes.
14. Petroleum kills by ______ and ______ .

613. Complete given statements concerning the methods used for controlling adult mosquitoes.

You can effectively control adult mosquitoes by using mechanical and chemical controls.

Mechanical Control. Adequate screening of all occupied structures is a must. Bed nets should be used under field conditions when screening of structures is impossible or impractical.

Screening. Screens are made of galvanized iron, copper, bronze, aluminum, or plastic. Near the ocean iron and copper screens are not recommended because of the corrosive action of salt sprays. Plastic screens have given years of good service in these areas. Screens must be of the proper mesh, must fit tightly and be kept in good repair. The ordinary window screen with 16 × 16 or 14 × 18 meshes to the inch will keep out most mosquitoes, but screens with 16 × 20 or 23 mesh may be necessary in areas with small mosquitoes, such as *Aedes aegypti* and *Aedes taeniorhynchus,* according to most authorities. Frequently, mosquitoes follow people into buildings or enter on the human host. For this reason, screen doors should open outward and have automatic closing devices. Residual insecticide applications on and around screen doors give added protection. Xylene emulsions of insecticides often affect the galvanizing on ordinary iron screens, with subsequent rust problems, and may affect some plastic screens. Therefore, kerosene solutions are preferable for such residual sprays.

Bed nets. The bed net, or mosquito bar, is a useful item in temporary camps and in the Tropics. Mosquito netting is a cotton or nylon cloth with 23 to 26 meshes per inch. White netting is best, as mosquitoes accidentally admitted into the net are easily seen and killed. Most bed nets are rectangular in shape and large enough to permit a person to sit up in bed. The net is suspended over the bed and tucked in under the mattress. An aerosol bomb may be used to kill mosquitoes in the net before the person retires, or they can be killed by hand.

Chemical Control. Adult mosquitoes can be controlled effectively by applying chemicals as aerosols, mists, fogs, dusts, and residuals.

Aerosols. Aerosol bombs are used to kill mosquitoes in homes, temporary lodging facilities, and field tents. A few seconds' release of the aerosol will kill all species of mosquitoes (and flies, midges, and gnats) in an ordinary-sized room, tent, or trailer. It is not hazardous to humans if used as directed on the container.

Fogging and misting. Fogging and misting operations are conducted during the late afternoon and early evening, at night, or in the early morning when the air is calm, or winds vary from 1 to 6 miles an hour. If winds are exceptionally strong, fogs and mists are dispersed so swiftly that effectiveness is reduced. Similarly, fogs generated during the middle of a hot day, may drift across hot pavements or roads and be dispersed by rising currents of warm air known as *thermals.* By contrast, at night, there may be an *inversion* of air temperature so that fogs are held close to the ground as thick, long-lasting blankets, producing excellent control of mosquitoes. Under normal operating conditions, *the space-spraying machines travel at 3 to 7 (averaging 5) miles per hour.* Some of the larger thermal fog generators have a rated maximum output of about 40 gallons per hour, but normally disperse 15 to 25 gallons per hour. Many of the larger mist machines have a greater output.

Outdoor space treatments with mist or fog machines have been carried out effectively against species of *Aedes, Culex, Mansonia,* and *Psorophora* mosquitoes. DDT was formerly the insecticide of choice as a space spray, but the development of resistance to this and other chlorinated hydrocarbons as well as the residue problem, have led to the use of the less persistent organic phosphorus and carbamate compounds. Susceptible populations of mosquitoes can be reduced effectively by the use of fuel oil solutions containing pesticides that are recommended for this use in accordance with the pesticide label and Appendix A (included in a separate supplement).

For example, when 40 gallons or more of 6 percent malathion fog solution is applied per hour over a swath width of one city block (about 300 feet) at a vehicle speed of 5 miles per hour downwind, good control of adult mosquitoes will ensue.

Tests in Florida and Georgia have shown little difference in the biological efficacy of thermal and nonthermal fogs. A number of "cold foggers" have been developed which give effective control in experimental field trials.

Mist applicators can be calibrated to give applications of as much as 0.5 pound per acre in wind velocities as high as 10 miles per hour. Mists settle much more rapidly than fogs. The problem lies in obtaining a sufficiently small particle size to obtain an adequate swath width.

Space spraying is the chief activity of many organized mosquito abatement districts and is (wrongly) the only method used by an even larger number of communities which attempt to reduce mosquito annoyance.

Control of adult mosquitoes by space spraying gives only temporary control. If mosquito populations are high, and the species are strong fliers, such as pest mosquitoes in the genera *Aedes, Culex, Mansonia,* and *Psorophora,* migration back into the area may occur following treatment making daily applications necessary.

Dusting. In past years there has been much interest in the use of dusts for adult mosquito control. Three percent gamma isomer BHC agricultural dusts have been used for emergency mosquito control in many parts of the country. It has given good results because of the immediate knockdown and a short residual action when resting mosquitoes came in contact with the dust particles on vegetation. Recent tests in Georgia and Florida with ground-dispersed dusts (10% and 7.5%) of carbaryl produced 99 percent reduction of adult salt-marsh mosquitoes at dosages of 0.2 and 0.3 pound of carbaryl per acre.

Residual sprays. Residual spraying is the application of an insecticide to a surface in order to leave a film, or a deposit of crystals, which will kill insects for weeks or months thereafter. This method is particularly adapted to the control of *Anopheles* mosquitoes because of their habit of entering buildings and resting on surfaces. This method can also be used against other house-frequenting mosquitoes including important vectors of encephalitis, such as *Culex tarsalis,* and *Culex quinquefasciatus,* or carriers of yellow fever and dengue, such as *Aedes aegypti.*

The insecticides are usually chlorinated hydrocarbons or organic phosphorus compounds applied as solutions, emulsions, or suspensions. In the United States, oil solutions or water emulsions have been widely used because these formulations do not leave unsightly deposits in houses with painted walls, wallpaper, or good furniture. In most tropical areas, water suspensions have been used because of economy in transporting and handling water-wettable powders. The powdery deposit of these suspensions is not particularly noticeable of objectionable on mud, adobe, or thatched walls or roofs, and the insecticide is readily available to kill mosquitoes, rather than being absorbed into the sprayed surfaces as is the case with solutions or emulsions.

Exercises (613):

1. Screens of iron and copper are not recommended near the __________ because of the __________ of __________ .
2. The *Aedes aegypti* mosquito requires screen with ____________________ or ________________ mesh.

3. Since mosquitoes follow hosts into buildings, screen doors should open ________ and have ________ devices.
4. The bed net, or ________, is a useful item in ________ camps and in the ________.
5. An aerosol bomb may be used to kill mosquitoes in the ________ before the person retires, or they can be ________ ________.
6. Aerosol insecticides are not hazardous to ________ if used according to ________.
7. Fogging and misting operations are conducted during the ________, ________, ________, or in the ________ when the air is ________.
8. Under normal conditions the space-spraying machines travel at an average speed of ________ miles per hour.
9. Some of the larger thermal fog generators have a rated maximum output of about ________ gallons per hour.
10. Tests in Florida and Georgia have shown ________ difference in the biological efficacy of thermal and ________ fogs.
11. Mists settle much more ________ than fogs.
12. Control of adult mosquitoes by space spraying effects only ________ control.
13. Dust control has given good results because of the immediate ________ and short ________.
14. Residual spraying leaves a ________ which is effective for ________ or ________ afterward.

CHAPTER 2

Flies

FLIES ARE PESTS both indoors and out. More important, many flies breed in excrement and filth from which they carry disease-causing organisms to food, drinking water, or directly to the human body. Throughout the world, flies serve as mechanical and biological carriers of organisms that cause some of the most common and important diseases, such as typhoid fever, diarrhea, dysentery, cholera, trachoma, African sleeping sickness, and onchocerciasis. Larvae of some species of flies infest man or animals and cause serious sickness or even death, while other species attack and destroy crops. Today it is recognized that the abatement of fly population is essential to human well-being and the control of many serious and widespread diseases.

You can control flies most effectively if you can identify species, know the life cycle and habits of problem species, and understand the dynamics of fly populations. Present methods of fly control are only partially effective; ready answers cannot be given to every fly problem. However, recognized techniques, judiciously employed, can often reduce the numbers of flies and decrease the transmission of flyborne diseases. Improved environmental sanitation, the primary control measure, reduces the prevalence of many fly species and furnishes dividends in better living conditions for people.

2-1. Ways in Which Flies Become Important to Humans

Flies are important to humans because of their annoying habits and ability to spread diseases and destroy agricultural products.

614. List the ways in which flies are important to humans and name the diseases that certain flies carry or create.

Annoy. Domestic flies can affect individual efficiency and productivity because of the amount of time that is expended swatting and driving flies away. Domestic flies can affect morale of individuals because of disruptions to picnics and other outdoor recreational activities.

Bite. Not all flies bite, but those that do may cause serious trouble. Biting flies do not have venom in the usual sense. Instead the effects of their bites result from the human reaction to saliva poured into the bite wound to prevent clotting of the blood during the feeding process. Frequently, biting flies, such as blackflies, punkies, horseflies, and deerflies, seriously interfere with such activities as farming, hiking, camping, and outdoor sports, particularly in coastal areas or in the northern part of the United States. In susceptible individuals, the bites of these insects may produce severe lesions, hard knots beneath the skin, secondary infections, high fever, and general disability. The stable fly is common around human habitations and its bite can be quite severe. Blackflies bite viciously, sometimes attacking in such numbers that they kill the victim. In the Balkans in 1923, over 16,000 domestic animals were killed by blackfly attack. Eye gnats do not bite, but their rasping mouthparts damage the delicate membranes of the eye.

Transmit Deseases. Flies transmit disease both mechanically and biologically. Many flies, particularly the housefly and other domestic flies, have filthy habits that make them efficient vectors of disease. Flies spread pathogens (desease-causing organisms) in five ways: (1) on their mouthparts, (2) through their vomitus, (3) on their body hairs, (4) on the sticky pads of their feet, and (5) through the intestinal tract by means of fly feces. The housefly is considered by many authorities to be the most widely distributed as well as the most dangerous insect closely associated with humans.

Mechanical. Under optimum conditions, flies can be as effective in spreading enteric infections as are fingers, dirty eating utensils, and contaminated food. As a typical example, a housefly feeds on human feces in a privy used by a person suffering from diarrhea and later alights on food being prepared in a kitchen. The fly inoculates the food with pathogenic bacteria, such as the diarrhea bacteria (Shigella) or the typhoid bacillus (Salmonella typhi), which multiply rapidly in the food. When, hours later, the food is eaten, the people become infected and develop diarrhea.

Domestic flies (particularly the housefly) mechanically transmit organisms causing baciliary dysentery, infantile diarrhea, typhoid fever, paratyphoid fever, cholera, amoebic dysentery, giardiasis, and pinworm, roundworm, and tapeworm infections.

Flies with rasping mouthparts, such as eye gnats, are reported to carry the organisms that cause trachoma, epidemic pinkeye or conjunctivitis, and yaws. There is also evidence that the organisms that cause tularemia and anthrax are transmitted mechanically on the mouthparts of deerflies and horseflies from an infected animal to a healthy one.

Bilogical. Many species of bloodsucking flies serve both as vectors and as intermediate hosts of pathogens, particularly of protozoa and helminths causing human diseases. This phenomenon is known as the biological transmission of disease-causing organisms. Examples include the tsetse flies of Africa which transmit the trypanosomes causing African sleeping sickness of humans and nagana of animals, the blackflies which transmit the worms causing onchocerciasis (blinding filariasis) in Africa and Latin America, and the sandflies which transmit protozoa causing many forms of leishmaniases in Europe, Asia, Africa, and Central and South America. Other diseases having this type of epidemiology include loasis (African eye worm disease), bartonellosis (oroya fever) of South America, and sandfly fever of the Mediterranean region.

Producers of Myiasis. Many species of flies lay their eggs or larvae on the flesh of mammals, including man. The larvae then invade the flesh of the host animal, producing a condition known as myiasis. Cattle and sheep are commonly afflicted, as are many wild animals, such as rabbits and deer. Typical examples of this type of myiasis are the screwworm maggots in cattle and the botfly larvae in horses. In addition, people may eat food infested with fly larvae. If the larvae survive the gastric juices and live in the alimentary canal, *intestinal myiasis* manifested by queasiness and diarrhea frequently results. Typical examples of intestinal myiasis are caused by eating such foods as fish, meat, or cheese infested with flesh fly larvae or cheese skippers, or by drinking water containing rat-tailed maggots.

Destroy Agricultural Products. Many species of flies, such as the Hesstan fly, cabbage maggot, onion maggot, apple maggot, clover seed midge, and seed corn maggot, attack and damage plants directly. Some flies transmit organisms causing plant disease, such as bacterial soft rot of vegetables; fire blight of apple, pear, and quince; ergot of rye and wheat; olive knot; and bacterial rot of apple. In addition, flies suck blood and annoy cattle to such an extent as to decrease milk and meat production, cause myiasis in many domestic animals, and transmit diseases such as anthrax.

Exercises (614):

1. List five major ways in which flies affect humans.

2. In what five ways do flies spread pathogens?

3. List six diseases that domestic flies can transmit mechanically.

4. What disease can occur if people eat food infested with fly larvae and the larvae survive the gastric juices?

2-2. General Characteristics of Flies

There are certain anatomical and life cycle characteristics common to most flies. Flies are insects belonging to the order Diptera.

615. Indicate whether given statements pertaining to the general characteristics of flies are true or false and correct the false ones.

Anatomy. Adult Diptera are distinguished from all other insects by the following two characters: (1) two wings (the scientific name is derived from Di = two + pteron = wing), whereas most other adult insects have four wings; and (2) two halteres, the tiny knoblike structures located behind the wings that represent the rudimentary second pair of wings. The relatively few wingless adult flies always have halteres.

Adult flies have three distinct body regions: head, thorax, and abdomen. The head bears a pair of very large compound eyes which often comprise most of the head, one pair of antennae or "feelers," and the mouthparts, which are adapted for piercing and sucking, rasping, or sponging, depending on the species. The thorax consists of three segments called the prothorax, mesothorax, and metathorax, each of which bears a pair of legs. Each leg is composed of a basal, cosa, short trochanter, relatively strout femur, slender tibia, and a five-segmented tarsus. The single pair of wings is fastened to the mesothorax and the halteres to the metathorax. The long veins which reach the wing margin in domestic flies are termed Sc (for subcosta), then 1, 2, 3, 4, 5, 6. The shape of the vein 4 (straight, curved, or angled) is used in identification (see Appendix B). The abdomen is composed of from four to nine segments and the genital organs.

Life Cycle. Flies have four stages in their life cycle: egg, larva, pupa, and adult. They develop by a process known as complete metamorphosis (fig. 2-1). A few species, such as some flesh flies and tsetse flies, retain the eggs within the body of the female until hatching and give birth to larvae. In general, the larvae feed differently and occupy a different habitat from that of the adult. Larvae of most flies are commonly termed "maggots." The pupae of many flies are enclosed in a tough skin known as a puparium and

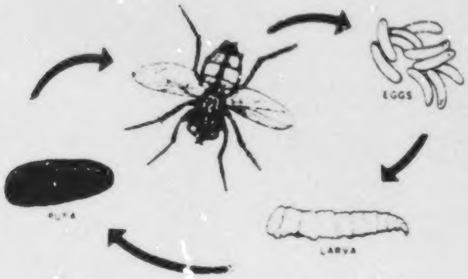

Figure 2-1. Life cycle of housefly.

do not move very much. The time required for development from egg to the adult varies greatly, from a few days to more than a year, depending on the species of fly, and the environmental conditions, particularly the temperature and humidity.

Exercises (615):

Label the following statements with a C or an I to indicate correct or incorrect; supply information to correct the incorrect statements.

____ 1. Flies belong to the order Diptera and have two wings.

____ 2. All flies have mouthparts that are adapted for piercing and sucking, rasping, and sponging.

____ 3. Each section of the thorax has a pair of legs.

____ 4. The abdomen is used for identification.

____ 5. Flies have five stages in their life cycle: egg, larva, pupa, maggot, and adult.

____ 6. Some female flies give birth to larvae.

____ 7. The larvae of most flies are commonly called maggots.

2-3. Fly Species

Some of the fly species with which you should be familiar are houseflies, other domestic flies, flesh flies, bottle flies, blowflies, and botflies. There are also some of lesser importance for you to study in this section. First, you will read about the housefly, one of the most common around humans.

616. Complete given statements concerning the identification and biology of houseflies.

Identification and Biology of the Housefly (Musca domestica). The housefly (fig. 2-2) is a small species, 6 to 9 millimeters (mm) long with a dull thorax and abdomen, the thorax with four longitudinal dark stripes, the sides of the abdomen usually pale basally, and the fourth wing vein sharply angled, ending before the wing tip. The arista of the antenna has many fine hairs like a feather.

The housefly and its relatives are often termed "domestic" species because of their close association with man. The adults feed on human foods, and the larvae are often most abundant in human wastes such as excrement, garbage, and open dumps.

The housefly occurs throughout the United States and is usually the most abundant species found in homes and restraurants.

Because of the housefly's close association with people and their food, its habit of breeding in human excrement and other filth, its abundance, and its ability to transmit germs, it is considered to be a greater threat to human welfare than any of the other species.

Life Cycle. The development stages of the housefly require 8 to 20 days under average summer conditions (fig. 2-1). The female begins egg laying within 4 to 20 days after she emerges as an adult. The small, white, oval eggs about 1 millimeter long are deposited in batches of 75 to 150. Five or six batches are laid during the lifetime of the average female, for a total of about 500 eggs per female. Eggs are usually placed in cracks and crevices in the breeding material away from direct light. Hatching occurs in 12 to 24 hours during the summer months. The active young larva burrows at once into the breeding media using its two mouth hooks for tearing and loosening food particles and for working its way along. The three larval stages last from 3 to 24 or more days. The usual time during warm weather is 4 to 7 days. Larvae regulate their temperature by moving to various levels in the breeding material. Studies indicate that feeding larvae choose temperatures from 86° to 95° F. (30.24 to 35.28° C.) those ready to pupate prefer lower temperatures. The distribution of larvae in the breeding media under natural conditions is believed to depend chiefly on temperature and moisture and, to a lesser extent, upon odors. When growth is completed, larvae migrate to drier portions of the media or leave it entirely to burrow into soil or under debris to pupate.

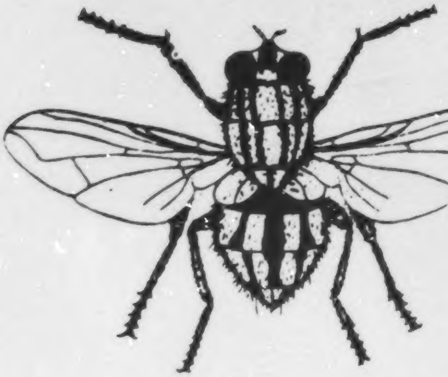

Figure 2-2. Housefly (*Musca domstica*).

The mature larva is about 12 mm long and creamy white in color. It is conical and has two dark mouth hooks at the anterior end and two oval spiracular plates at the broad posterior end. It is easily distinguished from other fly larvae by the three sinuous slits in each spiracular plate.

When ready to pupate, the larva contracts until the skin forms a capsulelike case about 6 mm in length. This case (the puparium) encloses the true pupa which is immobile and takes no food. The pupal stage ordinarily lasts 4 to 5 days, but may be as short as 3 days at temperatures around 95° F. (35.28° C.) or as long as several weeks at low temperatures. When the pupal period is complete, the fly breaks open the end of the puparium by the expansion of a bladderlike organ, the ptilinum, located on the front of the head. The fly then works its way out of the puparium and up to the surface of the soil. Here the wings unfold and the body expands, dries, and hardens. This change requires about 1 hour under summer conditions. Adulthood is reached in about 15 hours. Mating may then take place.

Breeding Media. Almost any type of warm moist organic material may furnish suitable nourishment for housefly larvae. Animal manure is an excellent breeding medium, accounting for as many as 95 percent of the houseflies in some rural areas. Fresh horse manure may produce as many as 1200 larvae per pound. Manure of other animals (cows, pigs, rabbits, fowl, etc.) is also very suitable. Accumulations of fowl excrement are commonly infested with larvae, but scatter droppings in dry pens are seldom infested. Human excrement, often loaded with organisms pathogenic to humans, is a dangerous source of fly breeding. Breeding occurs in privies, in exposed feces, and in incompletely digested sludge from sewage treatment plants. Garbage and pet manure are almost always the important source of houseflies in urban communities. Fly breeding may be a problem if garbage is dumped indiscriminately on the premises or if it is stored in inadequate containers. Open garbage dumps, commonly present in and around cities, produce large numbers of flies.

Adult Food. The adult housefly is very active, moving about busily from one attractant to another throughout most of the daylight hours. It is strongly attracted to feces and other types of decaying organic material, as well as to milk and foods intended for human consumption. Under natural conditions, houseflies seek a wide variety of food substances and thereby obtain a balanced diet. Because of the nature of the houseflies' mouthparts, their food must be in the liquid state or must be readily soluble in their salivary and crop secretions. The liquid food is sucked up through the spongy labellum at the tip of the proboscis. Water is essential, and houseflies will not ordinarily live more than 48 hours without it. Sugar or starch is necessary for long life, and protein is required for production of eggs. Common sources of food are milk, sugar, blood, meat broth, and many other foods found commonly in and around human habitations. Two or three feedings a day are necessary. As the housefly moves about over various items, it periodically regurgitates liquid from the crop and tests the surface with its proboscis, producing light, strawcolored spots known as vomit spots. Darker spots which may be observed are fecal spots, commonly found on glass, walls, ceilings, light strings, electric wires, and on other surfaces upon which flies rest. Accumulations of fly specks are good indicators of habitual resting places of flies.

Resting Places. Flies rest much of the time and show a strong preference for edges. They rest indoors on light strings and electric wires, walls, ceilings, and other places. They rest outdoors chiefly on fences, electric wires, edges of buildings, weeds and vegetation, particuarly branches. Flies are essentially inactive at night. Their nighttime resting places are usually protected from the wind.

Flight. Housefly populations can disperse rapidly into new areas by flight. Although houseflies cruise at only about 4 miles per hour and wander somewhat aimlessly, they travel as far as 6 miles (as the crow flies) within 24 hours, and as far as 20 miles, eventually. Flight range tests using flies tagged with radioactive materials have been performed in a number of different parts of the United States. After releasing the radioactive flies, the scientists set out baited traps in concentric circles around the release point. Most of these tagged flies recovered were trapped within 1 mile, but a few were taken as far as 20 miles from the point of release.

Longevity. Lifespan of the adult depends chiefly upon the availability of food and water, and upon temperature. Observations during midsummer in Texas indicate that when well fed, flies live 2 to 4 weeks. At Ithaca, New York, adult flies survived 70 days under experimental conditions. In hibernation, flies may live over winter, often from October to April.

Temperature. Flies are inactive at temperatures below 45° F. (7.28° C.) and are killed by temperatures slightly below 32° F. (0° C.). Flight begins when air temperature is about 53° F. (11.76° C.) and complete activity occurs when it reaches about 70° F. (21.28° C.). Maximum activity is reached at 90° F. (32.48° C.) with a rapid decline at higher temperatures until 112° F. (44.80° C.) which produces paralysis and death.

Humidity. The effects of humidity are closely related to those of temperature, and it is difficult to assess one without considering the other. Lethal effects of both high and low temperatures are more marked when humidity is high. Above 60° F. (15.68° C.), flies live longest at a relative humidity of 42 to 55 percent. Below 68° F (20.16° C.), they are active and long lived. Flies reach a physiological optimum at high temperatures and low humidities. This characteristic correlates with their great abundance in desert areas.

Light. Flies are phototropic; that is, they generally move toward light. The success of the ordinary fly trap depends upon this trait. The bait attracts flies to the lower part of the trap, and they are captured when they leave the bait and move around toward the light. Flies are inactive at night, but they will resume activity under artificial illumination. The effects of light on fly activity are closely correlated with those of temperature and humidity.

Wind. Flies are sensitive to strong air currents and are not likely to venture out on extremely windy days. However, some are caught and carried great distances by high winds (such as hurricanes). Houseflies, probably windborne, have been collected over the ocean more than 100 miles from shore. At lower velocities, flies may travel with the wind or against it. They move upwind toward an attractive odor, against moderately strong winds, but move downwind on light breezes not bearing attractive odors.

Natural Enemies. Organisms in its environment are of great importance to the housefly. Most of these organisms do no harm, but some act as parasites or predators. Natural enemies of flies include fungi, bacteria, protozoa, roundworms, other arthropods, amphibians, reptiles, birds, and certain mammals, particularly humans.

Exercises (616):

1. The houseflies are often termed ____________ species because of their close ____________ with man.
2. The housefly occurs throughout the United States and is usually the most abundant species found in ____________ and ____________ .
3. The development stages of the housefly require ____________ to ____________ days under average summer conditions.
4. The female begins egg laying within ____________ to ____________ days after emergence as an adult.
5. ____________ or ____________ batches of eggs are laid during the lifetime of a female for a total of about ____________ eggs per female.
6. The true ____________ is immobile and takes no ____________
7. Almost any type of ____________ , ____________ , ____________ material may furnish suitable nourishment for housefly larvae.
8. Adult flies are strongly attracted to ____________ and other types of decaying ____________ material.
9. Under natural conditions, houseflies seek a ____________ of food substances and thereby obtain a ____________ .
10. Water is essential and houseflies will not ordinarily live more than ____________ hours without it.
11. Accumulations of fly specks is a good indication of ____________ of flies.
12. Although houseflies cruise at only about ______ miles per hour and wander aimlessly, they travel about ____________ miles within 24 hours and as far as ____________ miles eventually.
13. Lifespan of the adult depends chiefly upon the availability of ____________ and ____________ and upon ____________ .
14. Flies are inactive at temperatures below ______ .
15. Flies are killed at a minimum temperature below ____________ and a maximum temperature above ____________
16. Lethal effects of both high and low temperature are more marked when relative humidity is ____________ .
17. Flies are phototropic; that is, they generally move ____________ .
18. Flies are sensitive to strong ____________ and are not likely to venture out on ____________ days.
19. Natural enemies of flies include ____________ , ____________ , ____________ , ____________ , other ____________ , ____________ , ____________ ____________ , and certain ____________ .

617. Match each item in a list of domestic flies with statements pertaining to their importance and biological factors.

Little Houseflies *(Fannia spp)*. Little houseflies are small flies seldom more than 7 mm long. They resemble houseflies in having a full thorax and abdomen, but differ in having only three relatively inconspicuous dark longitudinal stripes on the thorax and the fourth wing vein is straight (Appendix B). The adults are frequently seen hovering in midair outdoors or less commonly in the middle of a room, a chicken house, or a barn. Little houseflies lay their eggs particularly in the excrement of humans, horses, cows, and poultry, or sometimes in piles of decaying grasses piled up on lawns. The eggs hatch in about a day and the flattened, spiny larvae complete their development in a week or two depending on temperature. *Fannia* are of less importance as household pests or disease vectors than the housefly. However, there are numerous records of larvae of this genus causing myiasis in man.

Stable Fly *(Stomoxys calcitrans)*. The stable fly is distinguished from all other common domestic flies by its piercing proboscis which protrudes bayonetlike in front of the head (fig. 2-3). This species is 5 to 7 mm long, has a dull thorax with four dark longitudinal stripes, a pale spot behind the head, and a dull colored abdomen with dark spots. The fourth wing vein is gently curved and ends near the wing tip. The arista of the antenna has fine hairs only on the upper side. Both male and female are vicious biters and attack man and a great variety of animals. The female lays her eggs in plant waste more often than in manure. She may lay eggs in old strawstacks, piles of fermenting weeds, grass, peanut hay, or stable manure well mixed with straw or hay. The stable fly is a major pest along the seashore, particularly on the gulf coast, where it is known as the dog fly. It lays its eggs in piles of marine weeds on the beaches and is a serious pest in late summer and early fall. Larval development takes 8 to 30 days or more, depending on temperature. The stable fly is not considered an important agent in mechanical transmission of organisms causing intestinal diseases. It does not breed in human excrement and is not commonly attracted to feces or garbage. It is therefore, less likely to pick up germs of diarrhea and other intestinal diseases.

Because of its bloodsucking habits, the stable fly has been suspected of transmitting a number of diseases but there is no proof that it is a biological vector of surra (a trypansonal disease of horses and mules) and infectious anemia (a virus disease of horses). Stable fly larvae have been reported as causing myiasis of humans and of domestic animals.

False Stable Flies ***(Muscina spp).*** False stable flies are slightly larger and have heavier bodies then house flies, averaging about 8 mm long. These insects have a dull thorax and abdomen, with blackish markings, like the housefly, but differ in having a pale tip to the scuttellum and the fourth wing vein gently curved and ending about at the wing tip (Appendix B).

False stable flies breed in decaying animal and vegetable matter and are commonly found in scattered garbage. The larvae become carnivorous as they near maturity and destroy other fly larvae that they encounter. Larval development averages 15 to 25 days. The adult fly enters houses frequently and is attracted to human foods, including meat, fruit, and vegetables. It is a vector of disease organisms, and there are reports of cases of human intestinal myiasis that probably resulted from ingesting foods containing eggs of *Muscina*.

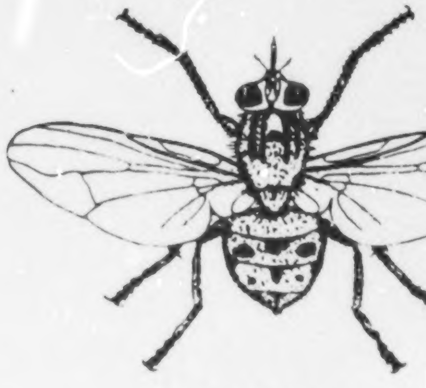

Figure 2-3. Stable fly

Tsetse Flies ***(Glossina spp).*** Tsetse flies are found in tropical and subtropical Africa. They vary in size from that of a housefly to that of a flesh fly, are usually brownish in color, and have a bloodsucking type of proboscis similar to that of the stable fly. The arista of the antenna has branched hairs on the upper side. The wing is remarkable in having the discal cell shaped like a meat cleaver, and is often called the "cleaver cell." Tsetse flies are biological carriers of the trypanosomes that cause two forms of African sleeping sickness (Gambian in West Africa and Rhodesian in East Africa) in humans and nagana in cattle and in many types of hoofed animals. These insects are, therefore, of greatest public health importance in causing sickness and death in humans and animals, and in depriving man of a source of meat and milk and animals for agriculture.

Dump Flies ***(Ophyra spp).*** Dump flies are shiny black flies, smaller than the housefly, with the fourth wing vein straight (Appendix B). Dump flies are widely distributed throughout the United States and are frequently abundant in cities. They are often found in fly trap collections, particularly those set near garbage disposal sites, hence their common name. Some researchers report that the larvae develop in human and animal excrement, kitchen wastes, and animal carcasses. Second and third stage larvae are predaceous on other fly larvae and may help reduce populations of housefly larvae.

Exercises (617):

Match the domestic fly species in column B with the statements concerning their importance and biological factors in column A.

Column A

_____ 1. They are of less importance than houseflies as household pests or disease vectors.

_____ 2. Second and third stage larvae are predeceous on other fly larvae and may help reduce populations of housefly larvae.

_____ 3. Both male and female are vicious biters and attack man and a great variety of animals.

_____ 4. Biological carriers of trypanosomes that cause two forms of African sleeping sickness.

_____ 5. Breed in decaying animal and vegetable matter and are commonly found in decaying garbage.

Column B

a. False stable flies
b. Dump flies
c. Little houseflies
d. Tsetse flies
e. Stable flies

618. Complete given statements concerning the identification, importance, and habits of flesh flies.

Identification and Biology of Flesh Flies (Family Sarcophagidae). Flesh flies resemble the housefly in general appearance, but usually are larger and differ in having three dark longitudinal stripes on the thorax, a checkerboard pattern of grayish and dark spots on the abdomen, and the tip of the abdomen is usually reddish brown. The fourth wing vein is sharply angled and ends before the wing tip (Appendix B). There are hundreds of species of flesh flies in the family Sarcophagidae. They are common called flesh flies because the larvae of most species breed in meat, cheese, fish, and other foods left exposed on which flesh fly larvae were developing. Flesh flies are unusual in that the females deposit living larvae rather than eggs. Some species breed prolifically in animal excreta, especially in dog stools, and may be very abundant in urban communities. They do not enter homes nearly as often as houseflies. When they do, they are often found in kitchens and bathrooms. The females are strongly attracted by the scent of food, such as fish and meat, and to the odor of human excrement. They have been observed depositing larvae in containers with fecal samples in some laboratories, which has led to false reports of human intestinal myiasis. Some species of flesh flies in the genus *Wohlfahrtia* cause cutaneous myiasis in humans and are major pests at mink and fox farms, killing newborn or young animals.

Exercises (618):

1. Flesh flies resemble the housefly in general appearance, but usually are larger and differ in having ________ dark longitudinal stripes on the ________, a ________ pattern of grayish and dark spots on the ________, and the tip of the abdomen is usually ________.
2. The common name "flesh flies" probably originated because the larvae of most species breed in ________ and ________.
3. Flesh flies are unusual in that the female deposits ________ rather than eggs.
4. Some species of flesh flies in the genus *Wohlfahrtia* cause cutaneous myiasis in ________ and are major pests of ________ and ________ farms.

619. Match a list of bottle flies and blowflies with the appropriate identifying characteristics, and complete given statements concerning the importance and biology of these flies.

Bottle flies and blowflies (family Calliphoridea) lay their eggs upon animal carcasses and meat products, causing them to swell, "bottle," or "blow" with maggots. Many of the adult flies have the shiny color of blue or green bottles. They are common in most urban areas and are often abundant about garbage dumps, abattoirs, and meat processing plants. They have long flight ranges and a keen sense of smell that guides them to dead animals and other attractants, even when located in remote areas. They enter houses much less frequently than houseflies. The development stages are the same as for the housefly. Although they usually deposit their eggs upon meat, they will oviposit upon a wide range of fresh and decaying plant refuse if meat is not present. Eggs may be deposited on living animals, although clean, healthy animals are rarely attacked. Upon emerging from the egg, the larvae feed for a short time upon the surface of the food near the egg mass, then bore into the less putrid material within. When fully developed, they leave the breeding material and burrow into the ground. The puparium is formed within a few days and emergence occurs from 3 to 20 days after pupation. Calliphoridae serve as mechanical vectors of disease organisms in the same way as do houseflies. They have similar nonpiercing mouthparts and feed in much the same way. However, since they enter homes and restaurants less frequently than houseflies, they appear to have less opportunity for disseminating disease organisms to food. The larvae of many species cause animal and human myiasis.

Bluebottle Flies *(Cynomyopsis cadaveina* and *Calliphora).* Bluebottle flies are medium to large species, 10 to 15 mm long or more, with a dull thorax and shiny metallic blue, green, or purplish abdomen (fig. 2-4). They frequently enter buildings to hibernate during the winter and emerge when buildings are heated, or on warm winter days, causing annoyance as they fly around with a loud, buzzing sound. Bluebottle flies require 15 to 20 days or more to develop from egg to adult. The adult flies are attracted to flowers, feces, overripe fruits, and other decaying vegetable matter as well as to sores of living animals. Bluebottle fly larvae may cause intestinal myiasis.

Greenbottle Flies and Bronzebottle Flies *(Phaenicia spp* and others). Greenbottle and bronzebottle flies include many species in the genera *Phaenicia, Lucilia, Burolucilia* and other less common genera. These insects occur from the Atlantic to the Pacific and throughout the world.

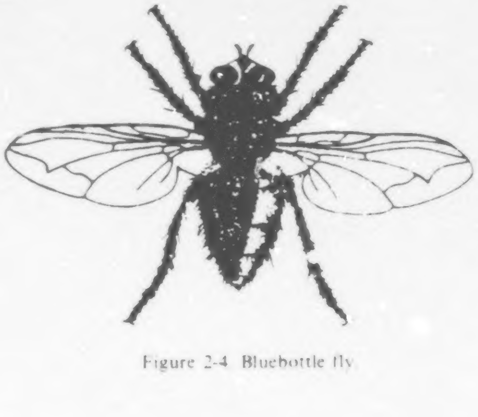

Figure 2-4. Bluebottle fly.

Two of the species most commonly associated with man in the United States are the greenbottle fly *(Phaenicia sericia)* (fig. 2-5), which has a shiny greenish thorax and abdomen, often with reddish or coppery reflections, and the bronzebottle fly *(Phaenicia pallescens)*, which has a shiny thorax and abdomen usually with coppery or bronzy reflections predominating over the greenish color (Appendix B). The life cycle is normally completed in 9 to 21 days with four to eight generations per year. The eggs are deposited on decomposing animal matter or in garbage containing mixtures of animal matter. Females are strongly attracted to flesh and oviposition begins with a few hours after the death of an animal. Fresh meat is often attacked within a few minutes after exposure. They also deposit eggs on wounds and occasionally cause intestinal myiasis. The average number of eggs produced at one time is about 180, although single females have been reported to deposit over 2000. The optimum temperature for development of eggs is about 94° F. (34.72° C.), and hatching occurs in about 8 hours at this temperature.

The larvae complete their development in 2 to 10 days and then move away from the breeding medium and burrow in the soil. The larval stage may be greatly prolonged if temperatures are low. These flies normally overwinter as full grown larvae in the soil. Pupation occurs within 3 days if temperatures are favorable, the pupal stage lasting 3 to 6 days under warm conditions. The adults may successfully emerge through several inches of earth (half of the flies emerging from puparia buried under 3 feet of loose soil reached the surface in experiments). Adults mate and deposit eggs 5 to 9 days after emergence The green bottle flies are most active on warm, sunny days. They are attracted to garbage (particularly where it contains mixtures of meat and fruit), plant juices, and nectar. They are often seen in large numbers on shrubbery, leaves of cucumbers and other melons, and on other plants. At times, particularly in the spring and fall, they enter houses and restaurants where they usually attract attention because of their buzzing flight. They may fly 10 miles from their breeding places within a few days. Favored nighttime resting places include trees, bushes, and sides of buildings.

Black Blowfly ***(Phormia regina)***. The black blowfly has a shiny black thorax and abdomen and metallic blue-green luster. The setae on the top of the thorax are noticeably shorter than in other calliphorid flies and the mesothoracic spiracle (on the side of the mesothorax behind the head) is brick red (fig. 2-6). This species occurs throughout the United States and is most abundant in the early spring. In the southern part of the United States it may be uncommon in summer, but is active on warm days throughout the winter. It is a mechanical carrier of organisms causing diarrhea and dysentery. It is a common producer of myiasis in sheep and cattle in the southwestern United States, where it is found in wounds, castration incisions, and dehorning incisions. The life cycle requires 10 to 25 days or more and is generally similar to that of the green bottle flies. The eggs are laid in masses in animal carcasses or in the edges of wounds in living animals. Larvae may occur in great numbers in animal carcasses or in paunch contents of slaughtered animals. They also breed abundantly in garbage. The larval stage requires 4 to 15 days and the pupal stage 3 to 13 days. The adults can deposit eggs 7 to 17 days after emergence. The adults are strong fliers and have an effective flight range of 6 to 10 miles. In the North they overwinter as full grown larvae, but in the South, as adults.

Cluster Fly ***(Pollenia rudis)***. The cluster fly is slightly larger than the housefly and the abdomen often has a slightly metallic reflection beneath a pollinose checkerboard pattern. It is easily recognized by the thick, yellowish-to-brassy, crinkled hair between the black setae on the top of the thorax and the tufts of yellowish hairs on the side of the thorax. The cluster fly is distributed throughout the Northern Hemisphere and is very common in the northern United States. The eggs are deposited in the soil and hatch in about 3 days. This species is most unusual in that the larvae are parasites of earthworms, within which they feed and grow for about 2 weeks. They then leave the earthworm and pupate in the soil for about two weeks. Newly emerged adults are often most abundant after rainfall, suggesting that the adults can burrow from their puparia to the surface easier when the soil is soft and moist. There are probably four generations or more a year in the United States.

Cluster flies derive their names from the fact that the adults enter buildings in the fall to hibernate and accumulate in clusters, in closets, attics, and unused rooms. They may be concentrated in open ceilings or walls, or may crawl behind window casings, moldings, loose wallpaper, pictures, or furniture. During mild weather in the winter or early spring, or if a cold building, such as a church, is heated occasionally, they move about sluggishly, often with a loud buzzing noise, thus attracting attention to their presence.

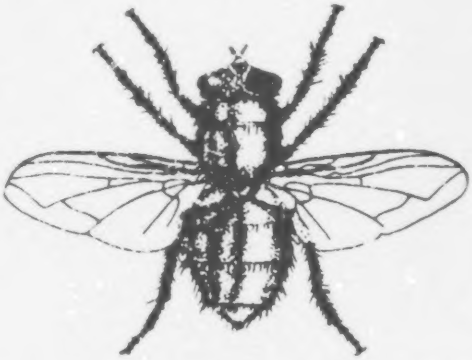

Figure 2-5. Greenbottle fly.

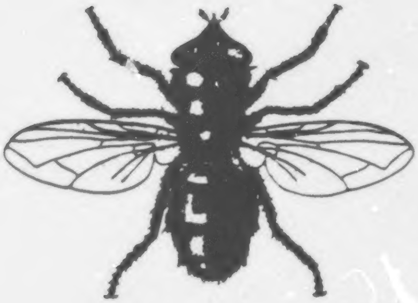

Figure 2-6. Black blowfly.

They are not of direct public health importance, but they may be a nuisance in buildings where they hibernate. In hospitals in the northern United States, there have been many complaints, for example, of cluster flies in operating rooms. The flies apparently entered these rooms through small openings around air ducts or electric fixtures from the cold attic above.

Screwworm Flies *(Cochliomyia spp).* Screwworm flies are slightly larger than the housefly and have a bright yellowish face and a shiny, blue-green thorax and abdomen. The thorax has three dark longitudinal stripes and the mesothoracic spiracle is white. The primary screwworm larva *(Cochliomyia hominivorax)* is an obligatory parasite responsible for most of the cases of screwworm infestations in animals and humans in the United States and in Latin America. The adults are rarely collected in ordinary fly traps. The secondary screwworm larva *(Cochliomyia macellaria)* is a scavenger and garbage feeder. The adults are often abundant in fly traps in the southern United States. The differences between the adults in these two species are minute. The larval tracheal trunks are deeply pigmented in the primary screwworm and less so in the secondary screwworm. The screwworm is the larva, or maggot, of the screwworm fly. The taper of the larva's body and the rings of spines that encircle it somewhat resemble a wood screw, hence its common name.

The primary screwworm *(Cochliomyia hominivorax)* is a tropical and subtropical species widespread in Latin America. Formerly it occurred throughout the year in southern Florida and Texas, but extended its range northward by flight and on shipments of domestic animals so that it occurred by fall as far north as Virginia, Iowa, and California. The primary screwworm is strictly parasitic, attacking only clean fresh wounds. It parasitizes cattle, sheep, goats, humans, and other animals. Infestation of 20 percent of the livestock have been reported in some areas, with mortality reaching 20 percent of those infested. In 1935, there were 1,200,000 cases in livestock and 55 cases in humans in Texas alone. However, by use of the sterile-male technique, beginning in 1958, the primary screwworm was eradicated from the United States east of the Mississippi River. Eradication west of the Mississippi is more difficult because of reintroduction from Mexico. The eggs of the primary screwworm are laid in single batches of 10 to 400 eggs in or near wounds. They hatch in 11 to 21 hours and the larvae penetrate the tissues, leaving their posterior ends exposed to the air. Feeding is completed in 4 to 8 days, after which they drop to the ground and enter the soil to pupate. The average life cycle under summer conditions requires about 24 days. Adults seem to be less active than other Calliphoridae, but they have a recorded flight range of 9 miles.

The secondary screwworm *(Cochliomyia macellaria)* is very similar to the primary screwworm in appearance. It occurs throughout the United States, but is seldom abundant in the North. This species does not infest living tissues, but it will infest wounds where it feeds upon the dead tissues. It is frequently involved in the "blowing" of meat in shops and homes, and may be of economic importance in this connection especially in abattoirs. The eggs are deposited in a loose, yellowish mass consisting of 40 to 250 eggs. They hatch in about 4 hours, the larvae feeding upon dead animal tissues. They reach maturity in 6 to 20 days and then crawl into the soil for pupation. The total time required for development into the adult stage ranges from 9 to 39 days, with development being most rapid in a warm, humid climate. Ten to 14 broods may be produced annually. The adults usually live 2 to 6 weeks. They feed on a variety of foods, from garbage to nectar. Dead animals and vegetation surrounding them have swarms with thousands of these flies. A maximum flight range of 15 miles has been recorded.

Exercises (619):

1. Match the bottle flies and blowflies in column A with the identifying characteristics in column B.

Column A	*Column B*
_____ 1. Bluebottle flies	a. Derives its name from the fact that it accumulates in closets, attics, and unused rooms to hibernate.
_____ 2. Greenbottle flies	b. They are 10 to 15 mm long or more, with a dull thorax and shiny metallic blue, green, or purplish abdomen.
_____ 3. Black blowflies	c. The fly has been eradicated from the United States east of the Mississippi river by the sterile-male technique.
_____ 4. Cluster flies	d. The optimum temperature for development of eggs is about 94° F. (34.72° C.).
_____ 5. Screwworm flies	e. In the North they overwinter as full grown larvae, but in the South, as adults.

2. Complete the following statements concerning the importance and biology of the bottlefly and blowfly.
   1. Bottle flies and blowflies lay their eggs upon animal carcasses and meat products __________ "bottle" or "blow" __________ .

2. Calliphoridae serve as mechanical vectors of __________ in the same way as do __________.
3. Bluebottle flies require __________ days or more to develop from egg to adult.
4. The life cycle of the greenbottle fly is normally completed in 9 to 21 days with __________ to __________ generations per year.
5. The black blowfly is a strong flyer and has an effective flight range of __________ miles.
6. The primary screwworm larva is an obligatory parasite responsible for most of the cases of screwworm infestations in __________ and __________ in the United States and __________ __________.

620. Complete given statements concerning the importance and life cycles of botflies.

Identification and Biology of Botflies (Families Cuterebridae, Oestridae, and Gasterophilidae). Botfly larvae cause myiasis in many kinds of domestic animals and in humans. These flies are in three different families, but the more important species can be discussed together. The human botfly *(Dermatobia hominis)* occurs in South and Central America and in Mexico. Its larvae parasitize birds and mammals, including man. The adult fly does not seek its host directly but uses as a vector some other species of insect or arachnid (as *Psorophora* mosquitoes, domestic flies, and ticks). The female captures a vector species, glues her eggs to it, and then releases it. When the vector alights on a warm-blooded animal, the eggs of the botfly hatch and the larvae penetrate the skin. Development requires from 50 to 100 days after which larvae emerge from the host, drop to the ground, and pupate. The rabbit and rodent bots *(Cuterebra spp)* are able to cause nasal and dermal myiasis in man as well as to parasitize their normal hosts.

The sheep botfly *(Oestrus ovis)* usually causes nasal myiasis in sheep but may cause myiasis of the human eye. It is worldwide in distribution. The cattle botflies or ox warbles *(Hypoderma spp)* are usually found in tumorous swellings on the backs of cattle, but they may cause myiasis in horses and humans. The larvae of horse botflies *(Gasterophilus spp)* usually live in the alimentary tracts of horses, asses, and related hosts. After completing development, they pass out with the feces, pupate, and the adults emerge. The adult female fastens her eggs to the hair or lips of a host animal. The larvae are either swallowed or they burrow under the skin, eventually reaching the alimentary canel where they fasten to the lining by means of their mouth hooks.

Exercises (620):

1. The human botfly occurs in __________ and __________ America and in __________.
2. The adult fly does not seek its host directly but uses as a __________ some other species of __________ or __________.
3. The sheep botfly usually causes nasal myiasis in sheep but may cause __________ of the __________ __________.
4. The cattle botfly or ox warbles are usually found in __________ on the __________ of cattle.
5. The larvae of horse botflies usually live in the __________ tracts of __________, __________, and related hosts.

621. Match a list of flies of moderate importance to humans with the appropriate descriptions, and complete given statements concerning these flies.

There are several flies that are important to us but to a smaller degree than those we have already discussed because they have less association with people in the United States.

Midges (Families Chaoboridae and Chironomidae). Midges are tiny flies, usually 1 to 4 millimeters long, which breed in water or damp soil. Adult midges do not bite. However, they may occur by the millions and be most annoying. It is sometimes difficult to keep them out of people's eyes and nostrils, particularly when the midges are attracted to lights. The Clear Lake gnat, a species of Chaoborid midge, is a serious pest in parts of California.

Adult midges cause trouble by getting into fresh paint, getting into paper factories and ruining sheets of paper, and staining the sides of painted buildings. Chironomid midge larvae are sometimes found in water reservoirs and are carried throughout the distribution system.

Eye Gnats (Family Chloropidae). Eye gnats are tiny, shiny black flies with reduced wing venation. The important genus Hippelates has a curved, blackish spine on the hind tibia (fig. 2-7). Eye gnats are often very abundant in the southern United States. They swarm about the face and eyes and rasp the eye membranes with their mouthparts. In the southern

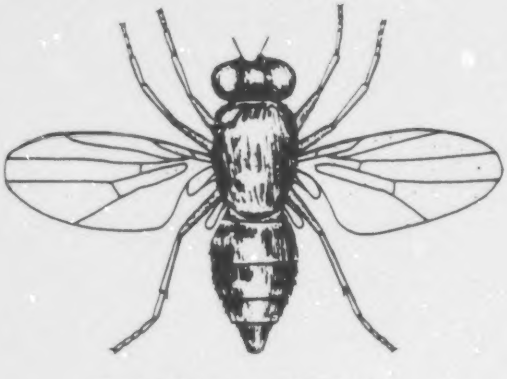

Figure 2-7. Eye gnat (*Hippelates*).

United States and in the Coachella Valley in California, eye gnats transmit organisms causing epidemic pinkeye, or conjunctivitis. Sometimes so many children are affected that the schools are actually closed for a week or more. The larvae of eye gnats breed in loose soil, frequently over vast areas of rich agricultural land, which makes control very difficult. The life cycle is completed in from 2 to 4 weeks.

Biting Gnats, Punkies, No-See-Ums (Family Ceratopogonidae). Some of the ceratopogonid midges in the genera *Culicoides* and *Leptoconops* are vicious biters. *Culicoides* are tiny flies, about the size of the head of a pin, generally with spotted wings and reduced wing venation (fig. 2-8). Their bites often cause intense pain, for many people worse than that of a mosquito. Important pest species include *Culicoides melleus, Culicoides hollensis* and *Culicoides furen* of the East and Gulf coasts and *Leptoconops torrens* and *Leptoconops kerteszi* in the South and West. Several species of *Culicoides*, called "punkies," "no-see-ums," or "sandflies," are so small that they can crawl through the ordinary 16-mesh window screen and be serious pests at summer camps, shore restaurants, and bathing beaches. In this country *Culicoides variipennis* transmits the virus that causes blue tongue of sheep. Outside the United States *Culicoides spp* are vectors of human filarial worms (*Mansonella ozzardi* and *Acanthocheilonema perstans)* and two types of worms *(Onchocerca cervicalis* of horses and mules and *Onchocerca gibsoni* affecting cattle) that cause animal dieseases.

Sandflies, Filter Flies and Moth Flies (Family Psychodidae). The family Psychodidae contains small fuzzy flies with hairy wings divided into two distinct groups: the filter and moth flies in the subfamily Psychodidae, whose females are not bloodsuckers, whose wings are held rooflike over the body, and whose larvae are commonly aquatic; and the sandflies in the subfamily Phlebotominae (fig. 2-9) whose females are bloodsuckers, whose wings are not held rooflike over the body, and whose larvae are typically terrestrial. The filter and moth fly group is widely distributed and abundant in most parts of the United States. Adult moth and filter flies are often found on bathroom and kitchen windows. Some common sources of domestic infestations are dirty garbage containers, water traps in plumbing fixtures, and accumulated gelatinous debris around the edge of sinks and wash basins built into counter tops. A common American moth fly is *Psychoda alternata.* Outdoors the larvae may be found in collections of dirty water and in decomposing organic materials, such as grass, plant litter, sewage, and garbage. Filter flies *(Psychoda spp)* are a serious problem at many sewage treatment plants. Some filter fly larvae may cause myiasis in man. In the Near and Far East, North Africa, and Central and South America, sandflies in the genera *Phlebotomus* and *Lutzomyia* may bite humans and transmit organisms causing sandfly fever, several types of leishmaniases and bartonellosis. Bloodsucking sandflies are comparatively rare and are not known to transmit human diseases in the United States. The adults have been found most often in hollow trees or in rodent burrows, and their immature stages may breed there. Recent taxonomic work places the important species of sandflies in Europe, Africa, and Asia in the genera *Phlebotomus* and *Sergentomyia* and the important, man-biting American species in the genus *Lutzomyia.*

Blackflies (Family Simulliidae). Blackflies (fig. 2-10) are nearly worldwide in distribution and second only to mosquitoes as bloodsucking pests of humans. They are small, 2 to 5 millimeters long, stout-bodied flies with short antennae, wings with the anterior veins well developed, and a humped thorax which has given them the common name "buffalo gnats." Both sexes suck nectar from flowers and most females suck blood. The eggs are laid in or near flowing water and the larvae and pupae are found attached to submerged rocks, sticks or vegetation. The adult emerges from the pupa in a submerged cocoon and floats to the surface of the water in a bubble of air. Many species mate soon after emergence.

Blackfly bites are painless at first, but later become swollen, hard, and painful, sometimes infected from scratching. Females of certain species attack humans while others confine themselves to mammals or birds. They swarm around exposed parts of the body, particularly the head, and get into the nose, eyes, ears, and mouth. Heavy attacks may be fatal to humans, cattle, horses, and poultry, possibly from toxemia, anaphylastic shock, or suffocation brought about by inhalation of large numbers of swarming insects. Several species transmit tularemia in North America, human onchocerciasis (blinding filariasis due to *Onchocerca volvulus)* in Africa and Central America and bovine onchocerciasis in Europe and Austrilia. Other species transmit deadly protozoa (Leucocytozoon) to ducks and turkeys.

Crane Flies (Family Tipulidae). Crane flies, which resemble mosquitoes superficially, are slender flies with long legs. They differ in having a V-shaped suture on the thorax and no scales on the wings. They breed in water, moist soil, and damp, rotting vegetation. Many species, 12 to 25 mm or more long, are attracted to lights and enter homes, thus causing

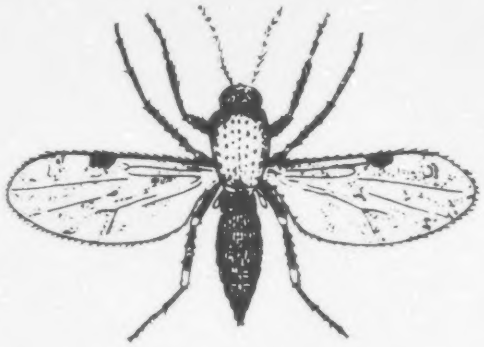

Figure 2-8 The biting midge

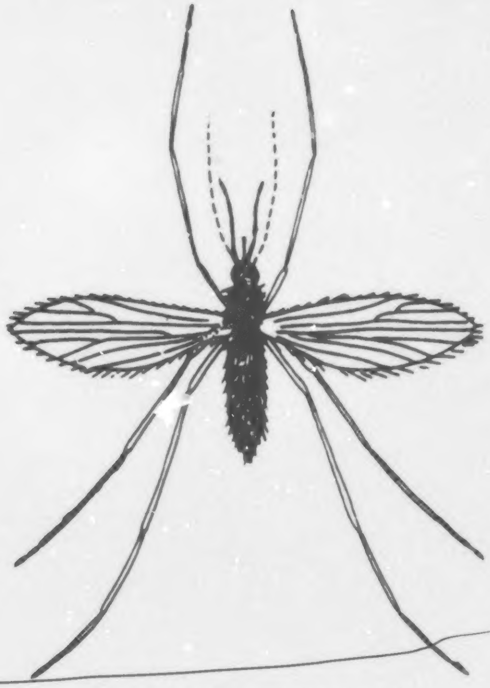

Figure 2-9. Sandfly (*Phlebotomus*).

complaints about invasion by "giant mosquitoes" even though they are unable to bite humans.

Hover or Flower Flies (Family Syrphidae). Hover or flower flies are small to large flies which resemble bees or wasps. Many of them are conspicuously marked with yellow and black. The distinguishing family characteristic is a pigmented line, called a spurious vein, on the wing. The larvae of some species breed in highly polluted water and have long breathing tubes which have caused them to be called "rat-tailed maggots." Sometimes these are very abundant at sewage treatment plants. Species of *Eristallis* and *Helophilus* occasionally cause human myiasis.

Horseflies and Deerflies (Family Tabanidae). Horseflies and deerflies rival mosquitoes and blackflies as annoying pests of humans and domestic and wild animals. Many are vicious biters and can inflict painful wounds that itch for days. Only the females suck blood; the males feed on plant nectar. In most parts of the United States deerflies *(Chrysops)* are more serious pests of man than horseflies *(Tabanus* and *Hybomitra)* which are major pests of cattle and horses. However, along the Atlantic coast, the salt-marsh greenheads *(Tabanus nigrovittatus)* are vicious pests of humans, particularly at bathing beaches. Other species of horseflies may be serious bloodsucking pests elsewhere. Many species deposit their eggs on vegetation near water, and their larvae develop in damp soil or water but some develop in dry pasturelands. In general, most species have one generation a year, but some of the larger species such as the black horsefly *(Tabanus atratus)* (fig. 2-11) may take 2 or 3 years for development.

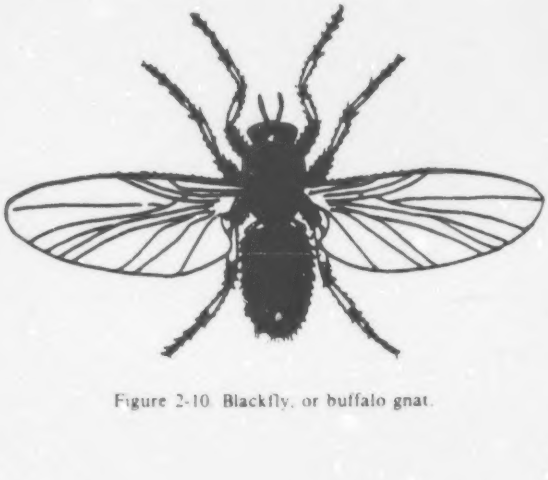

Figure 2-10. Blackfly, or buffalo gnat.

The family Tabanidae contains small to very large flies, 6 to 33 mm in length, generally recognized by the five posterior cells on the wing and the 3-segmented antenna.

Horseflies *(Tabanus)* usually are larger than deerflies and lack spurs on the hind tibiae.

Deerflies *(Chrysops)* average 6 to 12 mm long, generally have spotted wings, and have two spurs on the hind tibia (fig. 2-12).

Tabanidae are vectors of several diseases of man and animals caused by such organisms as viruses (equine infectious anemia, vesicular stomatitis, hog chloera, and California encephalitis), bacteria (anthrax and tularemia), rickettseae or rickettsia-like organisms (Q fever and anaplasmosis), trypanosomes (surra), and filarial worms (loasis and elaephorosis): In the United States deerflies, particularly *Chrysops discalis* are important in the mechanical transmission of tularemia in the West, where the disease is sometimes known locally as deerfly fever. Both deerflies and horseflies may serve as mechanical carriers of anthrax bacteria from domestic animals to man, particularly in southern United States.

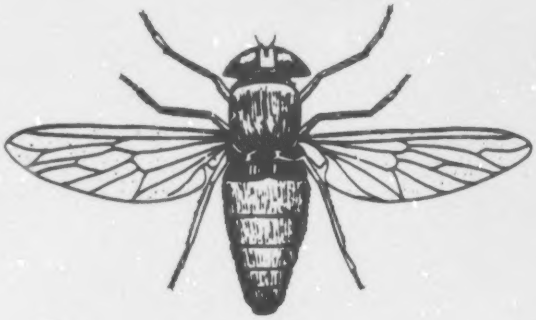

Figure 2-11. Horsefly.

Cheese Maggot and Related Forms (Family Piophilidae). The cheese skipper or maggot (Piophila casae) is about the size of the housefly. The larvae are slender and pointed toward the head end. At one stage the larvae are able to skip as much as 10 inches horizontally and 6 inches vertically by curving their bodies into rings, fastening their mouth hooks onto their abdomens, suddenly releasing their holds, and thowing themselves into the air. The life cycle requires 12 days or more. The adult deposits 140 to 500 eggs on cheese or hams. The adults transmit disease agents mechanically. The larvae cause intestinal myiasis in humans.

Soldier Flies (Family Stratiomyiidae). Soldier flies in the genus *Hermetia* breed in dacaying vegetation and organic materials and may cause intestinal myiasis in humans. These flies may be an important check on populations of domestic flies since the soldier fly larvae tend to keep material in privy pits soft and moist, an unfavorable habitat for housefly larvae.

Snipe Flies (Family Rhagionidea). Snipe flies breed in water or soil. Their larvae are predaceous. Members of the genera *Atherix, Rhagio, Spaniopsis,* and *Symphoromyia* bite man. They have not been shown to be the vectors of any human disease.

Vinegar Flies and Fruit Flies (Family Drosophilidae). Vinegar and fruit flies breed in decaying fruit and may suddenly become numerous in a house. The usual sources in the home are overripe fruit and dirty garbage containers. The fruit fly *(Drosophila melanogaster)* belongs in this family. Much of the knowledge of the science of genetics is based upon studies with this insect. Some species of *Drosophila* cause intestinal myiasis in humans.

Sheep Ked and Louse Flies (Family Hippoboscidae). Hippoboscidae are all ectoparasitic on birds and mammals. The sheep ked, *Melophagus ovinus,* is often found crawling on the bodies of sheephandlers and may inflict a painful bite. It is suspected of being a vector of Q fever in Canada. Bird louse flies, such as *Pseudolynchia canariensis* from the pigeon, may also be found on and biting man.

Exercises (621):

1. Match the name of the flies in column A with the statements in column B.

Column A

______ 1. Midges
______ 2. Eye gnats
______ 3. Biting gnats, punkies
______ 4. Sand, filter, and moth flies
______ 5. Blackflies
______ 6. Crane flies
______ 7. Hover or flower flies
______ 8. Horse and deerflies
______ 9. Cheese maggot and related forms
______ 10. Soldier flies
______ 11. Snipe flies
______ 12. Vinegar and fruit flies
______ 13. Sheep ked and louse flies

Column B

a. They have a "humped" thorax, which has given them the common name "buffalo gnats."
b. They are not known to be vectors of any human disease.
c. They may transmit organisms that cause pinkeye, or conjunctivitis.
d. Sometimes called "giant mosquitoes" even though they are unable to bite man.
e. Hippoboscidae are all ectoparasitic on birds and mammals.
f. Breed in decaying fruit and may suddenly become numerous in a house.
g. Tiny flies, usually 1 to 4 millimeters long, which breed in water or damp soil.
h. By curving their bodies into rings they can throw themselves about 10 inches horizontally or 6 inches vertically.
i. They rival mosquitoes and blackflies as the most annoying pest of humans and animals.
j. So small that they crawl through ordinary 16-mesh window screen.
k. Are comparatively rare and are not known to transmit human disease in the United States.
l. Breed in decaying vegetation and organic materials and may cause intestinal myiasis in humans.
m. The larvae are sometimes called rat-tailed maggots.

2. Complete the following statements concering flies.
   1. Chironomid midge larvae are sometimes found in ____________ .
   2. Eye gnats are tiny, shiny black flies with ____________ wing venation.
   3. *Culicoides variipennis* transmits the virus that causes ____________ .
   4. Adult moth and filter flies are often found on ____________ and ____________ windows.
   5. Blackflies are nearly worldwide in distribution and second only to mosquitoes as ____________ pests of humans.
   6. Crane flies, which resemble mosquitoes are slender flies with ____________ .
   7. Horseflies *(Tabanus)* usually are larger than deerflies and lack ____________ on the ____________ .
   8. The adults of the cheese skipper and related forms transmit disease agents ____________ and the larvae cause ____________ in humans.

2-4. Survey Methods and Control Measures

Fly surveys reveal what species of flies are present and furnish an index as to fly abundance in an area.

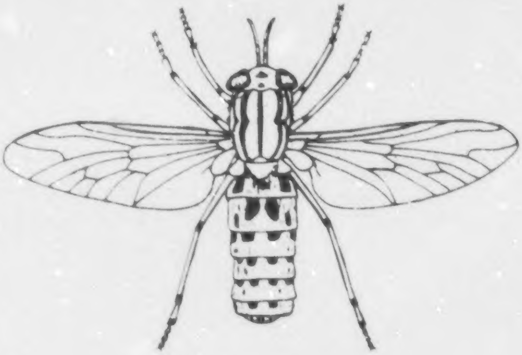

Figure 2-12. Deerfly.

By comparing your successive surveys, you can evaluate control effectiveness. Since it is not possible to determine the precise number of flies, surveys are designed to give an index of the population. A good survey will also show relative numbers of the various species. The method you use must be reliable enough that successive surveys can be compared. Reliability is limited by your skill, the errors inherent in the methods, and the fluctuations of fly population in response to environmental conditions.

The control measures that we will cover in this section include natural means, applied measures, such as environmental sanitation and chemical control, and integrated control. First, though, let's examine some methods for conducting surveys.

622. Complete given statements concerning the purpose of conducting fly surveys, the methods used to collect flies, and the use of information gained from the surveys.

Methods for Conducting Surveys. In determining fly populations and the need for control, *adult surveys* are usually more practical and reliable than *larval surveys*. Consequently, all commonly employed techniques are related to adult populations. The most generally used methods are the insect net surveys, fly trap surveys, and the fly grill surveys. The insect net and fly trap surveys are used to determine the *finds* of flies present in an area, whereas the fly grill surveys provide an *index* to the relative numbers of the various species in the fly population. None of these types of surveys gives an absolute *count* of the fly population present in an area.

Insect net surveys. The standard sweep net is often used to make a quick survey for adult flies, particularly at open dumps, cattle feed lots, or in epidemic or disaster areas where there are large amounts of decaying vegetables and fruits, dead animals, garbage, or refuse. The specimens can be killed with a chloroform or cyanide killing tube, determined, counted, and recorded.

Fly trap surveys. Trap surveys have the advantages of securing a reasonable cross section of the population for careful identification, making an approximate count of the relative numbers of the various species, and trapping flies alive for laboratory study. The two commonly used fly trap survey techniques are the baited trap and the cone trap. Bait traps are useful for determining the species present and, roughly, the relative numbers of the various species. A good bait trap must be durable, attractive, easily used, and should have some device for fastening it to the ground. Attach a suitable sign, such as "Do Not Touch, Conducting Fly Survey." Place an attractant in the pan under the trap. After the flies feed or deposit eggs on the bait, they move toward the light and enter the trap through a small opening in the cone. Since they do not generally fly downward to escape, and since the cone opening is difficult to find, few escape. Because not all flies respond to the same attractant, use an all-purpose bait: fish heads, chicken entrails, vegetables, and fruit. Place traps in different sections and in different types of blocks (slums, good housing, business, industrial, etc.). Flies are killed in chloroform jars, then identified and counted. Collections may be stored in boxes, such as ice cream cartons. Each collection should be labeled with date, location, method of collection, and name of collector. In extensive surveys a special form may be designed for recording data.

Fly cones are used primarily to collect live flies for bacteriological and virological study. The fly cone trap, made of screen wire, is placed over a natural attractant (garbage, manure, etc.), trapping flies beneath it. A dark cloth is thrown around the cone and the apparatus is carefully agitated. Attempting to escape, the flies move upward toward the light and enter the cage; then, the sliding door of the cage is closed and the collection is labeled. Flies may be taken to the laboratory for bacteriological and virological study.

Fly grill surveys. Fly grills are used widely in modern evaluation of fly populations. Fly grill surveys are faster than baited trap or fly cone surveys and give a valid picture of the fly situation. The fly grill depends upon the tendency of flies to rest on edges; it presents many attractive resting sites. The grill is placed over natural attractants (garbage, manure, etc.) and the number of flies landing on the grill during a 30-second interval is tabulated. When the grill is put down, the flies are disturbed from the attractant and fly upward for a short distance. When all is again quiet, they come back down, alighting on the grill instead of the attractant. If fly counts are so high that total counts become impracticable, you can divide the grill into halves, quarters, or sixths, with painted markings. You must count at least one-sixth of the grill. Make a minimum of 10 counts in each block sampled, and record the 5 highest counts. This piece of equipment is often called the Scudder fly grill, for Dr. Harvey Scudder of the Communicable Disease Center (CDC) who first developed this method of making adult fly surveys.

Reconnaissance surveys. Reconnaissance surveys are ordinarily used as a supplement to fly grill surveys. You take them in a vehicle or on foot by observing the abundance of flies in favored resting places and recording densities as estimated grill readings. These surveys provide data to guide control operations in areas lacking grill coverage, to facilitate rapid control in times of epidemic or disease, to serve as post-treatment evaluations of space spray applications, and to serve as preventive maintenance inspections during times of low fly density. Reconnaissance surveyors should be very familiar with fly grill survey methods.

Use of Survey Information. The success of fly control programs depends largely on close coordination of entomological surveillance and control activities.

By comparing data from survey to survey it is possible to find problem areas and to concentrate efforts to eliminate the most important breeding sites of flies. Primary emphasis should be given to environmental sanitation rather than insecticidal application. One of the best uses of survey data is in reports and publicity programs to make key officials and other base personnel more aware of program activities and to obtain their support.

Exercises (622):

1. Adult surveys are usually more practical and reliable than ____________ .
2. The standard insect sweep net is often used to make a quick survey for ____________ flies.
3. The two commonly used fly trap survey techniques are ____________ and ____________ .
4. Fly cones are used primarily to collect live flies for ____________ and ____________ study.
5. Fly grills are widely used in modern evaluation of ____________ .
6. Reconnaissance surveys are ordinarily used as a supplement to ____________ surveys.
7. Primary emphasis should be given to ____________ rather than insecticidal application.

623. Complete given statements concerning the natural measures that control flies.

Natural Fly Control Measures. The primary factors limiting the density of fly populations are the physical environment, including availability of food, water, shelter, and suitable breeding media; parasitism by viruses, rickettsiae, spirochetes, bacteria, fungi, protozoa, and roundworms; predation by centipedes, mites, spiders, pseudoscorpions, other insects, amphibians, reptiles, birds, and mammals; and competition of one fly with another for the benefits of the environment.

Fly populations are modified by reproduction, which is often tremendous; mortality, which is also enormous; and migration, which varies with the nature of environmental pressure. Many more flies are born than can survive. The numbers of flies an area can support is limited by the nature of the physical and biological environment. Excess flies must either migrate or die.

Example: Block A has an environment capable of supporting 1000 houseflies and of producing 125,000 additional flies every 2 weeks. The newly developed flies face severe competition for food, water, and shelter. They are killed by disease and predation. Some migrate and compete with neighboring fly populations. The small percentage surviving mate; and the females compete for suitable media in which to lay their eggs. Another 125,000 eggs hatch and the great struggle begins anew.

Many parasites and predators decrease domestic fly production. Some bacteria, such as *Bacillus thuringiensis*, have been used. The protozoan, *Octosporea muscaedomesticae*, may be an important factor in controlling the housefly and several other domestic flies. Some species of mites, such as *Macrocheles muscaedomesticae* prey upon flies. The larvae of a number of domestic flies, such as *Ophyra* and *Muscina*, feed on other species of fly larvae and have been reported to play a role in controlling houseflies.

All of these parasites and predators are normal inhabitants of manure. In order to derive maximum benefits from natural fly control, these parasites and predators must be permitted to live in the dung.

Exercises (623):

1. The numbers of flies an area can support is ____________ by the nature of the ____________ and ____________ environment.
2. The biological aspects that modifies fly populations are ____________ , ____________ , and migration.
3. The three most important physical environment factors that limit the density of fly populations is the availability of ____________ , ____________ , and ____________ .
4. In order to derive maximum benefits from natural fly control, ____________ and ____________ must be permitted to live in dung.

624. Provided statements pertaining to the biological, mechanical, and construction and maintenance control measures, identify the statements as being true or false.

The applied control measures that can be implemented against flies include biological, construction and maintenance, mechanical, sanitation, and chemical. The biological, construction and maintenance, and mechanical controls will be discussed within this objective. However, because of the extensive discussion that is required for the sanitation and chemical controls, these controls will be discussed in separate objectives.

Biological Control. Flies have been controlled by rearing tiny hymenopterous parasites and releasing them to prey upon certain species of flies. Many of the natural parasites, predators, and bacteria have been physically brought in and released in areas that are heavily infested with flies.

Controls have even been accomplished by sterilizing male flies and releasing them to mate with the females of the same species.

A classic example of the sterile-male technique to control or eradicate insects is the program which eradicated the primary screwworm *(Cochliomyia hominivorax)* from the southeastern United States. Millions of screwworms were reared in the laboratory. Males were sterilized with radioactive cobalt and liberated in the field where they mated with normal females. Since the female screwworm mates only once, eggs never hatched from the females that had mated with sterile males. The screwworm was eradicated from the southeastern United States in 1958 and 1959 with savings of millions of dollars annually to the cattle industry. However, in the southwestern United States the sterile-male technique has not been so successful because of constant reintroduction of screwworms from Mexico. If adequate numbers of vigorous and competitive sterile males are introduced into a natural population to mate with normal females, that population will soon cease to exist. The sterile males should outnumber the fertile males in the target population so that the chances of a sterile male mating with a normal female greatly exceed that of a fertile normal male. The sterile male technique has been attempted in controlling tsetse flies in Africa, houseflies in the United States, and fruit flies in the Pacific.

Mechanical Control. Controlling flies by means of mechanical measures includes the use of screens, fly traps, electrocution devices, and electric fans.

Screening. Screening buildings is the most widely used fly exclusion technique. Although costly, and not detrimental to the fly populations, this method can keep buildings virtually free of flies and will therefore be continued as long as major insect problems remain unsolved. Screens should be made of copper, aluminum, plastic, or some other noncorrodible material. They should be mounted in durable frames and should not detract from the appearance of a building. The screen size should be about 16 mesh (16 strands to the inch) in order to give the greatest protection without undue loss of light or air circulation. The screens should fit tightly in the window or door frames so that the flies and other insects cannot enter around the edges.

Fly traps. While useful for survey purposes, traps merely harvest the excess fly population and give little immediate relief, and no long range control. New research with fly attractants may add to the usefulness of fly traps in the future.

Electrocution. Electrocution has proven effective under certain situations. Two common techniques are used. In the first, a fly trap is electrified. In the second, electrification of window and door screens is accomplished using house current transformed to low amperage and high voltage (3500 to 4000 volts is desirable). When the flies alight on the screens, they are immediately killed, yet these screens will not harm a human being or other large animal. Installation of electric screen is very expensive. It has been used where the fly problem is acute.

Electric fans. Fans mounted over doorways leading to food service establishments will keep out a significant percentage of flies. Large buildings sometimes have air barriers or doors, to keep out dust, smoke, and insects, but which are hardly noticeable to persons passing in and out. Air velocities should be greater than 1500 feet per minute at a 3-foot level to obtain a reasonable degree of efficiency.

Construction and Maintenance Control. Base facilities should be constructed and maintained in a fashion that will exclude flies from entering. Doors and windows must fit snuggly and all holes leading to exterior portions of facilities must be sealed.

Exercises (624):

Mark the following statements as true or false.

____ 1. The applied control measures that can be implemented against flies include biological, construction and maintenance, mechanical, sanitation, and chemical.

____ 2. The primary screwworm fly has been eradicated from all parts of the United States through the sterile-male technique.

____ 3. Screening buildings is the most widely used fly exclusion technique.

____ 4. Fly traps provide good long-range control.

____ 5. Electrocution is a very effective method of fly control.

____ 6. Fans mounted over doorways leading to food service establishments will keep out a significant percentage of flies.

625. Complete given statements concerning environmental sanitation control of domestic flies.

Modern fly control programs involve both refuse control and environmental sanitation. Sewage and industrial wastes, while usually not the number one fly breeding sources, can be major fly producers. Since some of these wastes are heavily laden with germs, or pathogens causing diarrhea and dysentery, they become important beyond their volume from the public health standpoint. Animal feeds and excrement, plus a large number of minor breeding sources, can add significantly to the fly population. These sources should be sought out and eliminated in order to have an effective fly control program.

Refuse Storage. Sanitary refuse storage on all premises is the basic requirement for effective domestic fly control. At individual homes and small aprtments, metal or plastic garbage cans are suitable for storing garbage or refuse. Garbage cans should be of heavy-duty construction to prevent damage by collection personnel, rust-resistant, watertight, easy to clean, and easily handled by one man. They should have tightly fitting lids to exclude flies and recessed bottoms to prevent rusting, if made of metal. Ideally, all garbage should be placed in polyethylene or plastic bags to provide an additional barrier to fly breeding. Enough containers should be provided on all premises so that refuse need never be stored in boxes, cartons, bags, or simply left on the ground. Heavy plastic bags are widely used as liners for refuse containers, but they should not be used as substitutes for garbage cans. Plastic bags can be torn open by cats, dogs, and rats, and are often not fly-tight. Garbage cans should be kept on a neat and easily cleaned rack, platform, or slab. Spillage of garbage on soil can be a source of fly production. Cans should be of 20- to 32-gallon capacity or smaller. Larger cans make the job of collection too difficult. At large apartments and other establishments, such as restaurants, large metal bulk containers are more satisfactory generally than garbage cans. They should have lids which close automatically and be so constructed that they can be cleaned easily. Fly larvae are often found in the sludge in the bottom of garbage cans and bulk containers. Ashes and other heavy refuse may be stored in cans of 20-gallon capacity of less.

Refuse Collection. Under optimum summer temperatures, the eggs of domestic flies hatch in 12 to 24 hours, and the three larval stages are completed in 3 to 4 days. In order to prevent fly larvae in garbage cans and bulk contains from migrating out to pupate in the ground nearby, refuse should be collected from premises at regular intervals: twice weekly from residences and daily from high use areas, particularly food-handling establishments, transit quarters, and large apartments.

Refuse Disposal. The sanitary landfill is one of the most economical and adaptable methods of disposing of garbage and refuse. At a properly operated sanitary landfill, the most important practice to reduce fly breeding is compacting the refuse and covering it with 6 inches or more of earth *daily*. When the landfill is completed, a final cover of 24 inches of compacted earth effectively eliminates fly, mosquito, and rodent breeding. Low, swampy, submarginal land may be reclaimed as a byproduct, further reducing populations of mosquitoes and flies, and increasing property value.

Other Sanitation Measures. Minor breeding sources may play a greater or lesser role in the domestic fly problem. A concerted effort should be made to locate and eliminate as many of these as possible. Look for such things as animal feeds which are kept wet by rainfall, accumulations of animal manures improperly spread or poorly stored, dog stools, and other animal excrement not usually surveyed. In short, search out and eliminate any accumulation of organic material that remains moist long enough to produce flies.

Weeds are an open invitation for large populations of flies. They provide extensive and varied cover for the pests, make insecticide application difficult, and prevent adequate control of refuse, feces, and other breeding media.

Exercises (625):

Complete the following statements concerning the environmental sanitation control of flies.

1. Modern fly control programs involve both refuse control and ____________ .
2. Sanitary refuse storage on all premises is the basic requirement for ______________________________ .
3. Garbage cans should be of heavy-duty construction to ____________ by garbage collecters.
4. Under optimum summer temperatures, the eggs of domestic flies hatch in ________ hours.
5. The sanitary landfill is one of the most economical and adaptable methods of disposing of ________ ____________________ .
6. At a properly operated sanitary landfill, the most important practice to reduce fly breeding is ____________ the refuse and covering it with ____________ inches or more of earth daily.

626. Match given statements with the appropriate chemical control measures for domestic flies, and complete other given statements.

Chemical control procedures include residual sprays, fly baits, impregnated cords, space sprays, and larvicides. While each measure by itself may be effective to a certain extent, it is frequently desirable to use two or more methods at the proper time to achieve maximum control.

NOTE: The decision to apply any insecticide is the responsibility of the agency or individual concerned. Each person applying an insecticide should be certain that the intended use is in conformance with existing local, State, and Federal regulations and with the label information.

Residual Sprays. For many years residual sprays were one of the major methods of controlling houseflies. However, the housefly has developed resistance to many of the chlorinated hydrocarbon and organophosphate insecticides. Thus, these treatments are of little value in controlling this species, although they are effective against other such species as the little houseflies and blowflies. For outdoor application, the addition of sugar helps to prolong maximum effectiveness. Depending on the level of sanitation and the intensity of fly breeding, such residual spray treatments may have to be repeated as often as every 2 to 4 weeks.

Recommended chemicals to be used as residuals for controlling flies are provided in Appendix A in a separate supplement.

Fly Baits. Flies can be controlled by dry or liquid baits which possibly can be prepared from one of the pesticides recommended in Appendix A. Dry baits generally contain 1 to 2 percent of the insecticide and an attractant such as sugar, coated over an inert carrier, such as ground corncob, oyster shell, or sand. Liquid baits generally contain 0.1 to 0.2 percent of the insecticide and 10 percent sugar as an attractant dissolved in water. Commercial baits containing these insecticides are available, or the baits can be prepared from water-wettable powders or emulsifiable concentrates. Dry baits scattered by hand or from a sifter-type container produce dramatic reductions in fly populations within a few hours but are effective for only a day or two, particularly if placed on damp dirt surfaces. Permanent bait stations reduce the time and effort required to provide constant insecticidal pressure on the fly populations. These bait stations include simple plywood trays covered with hardware cloth for dry baits and chicken-watering fountains with a cellulose sponge in the trough to prevent clogging with dead flies for liquid baits. If the emulsifiable concentrate of the organophosphate insecticide is not readily available, you can place a piece of dichlorvos resin strip in the sugar water in the chicken-watering device. These are sometimes used to provide fly control in backyards near barbecue grills. People using fly baits should check regulations before applying them. Data from studies in Georgia and Florida indicate that flies resistant to residual sprays were killed by baits containing these same organophosphate insecticides.

Space Sprays. Space sprays are based on the concept of actually hitting the insects with a lethal particle of the insecticide. They do not provide a residual deposit of the toxicant and must be repeated periodically, sometimes before each meal in food-handling establishments or each day in dairy barns.

For indoor use householders frequently rely on hand-operated sprayers, or aerosol dispensers containing 0.1 to 12 percent of synergized pyrethrin or allethrin for quick knockdown of pest flies.

For outdoor use, space sprays have been used effectively at refuse dumps, near slaughter houses and cattle feed lots, and in alleys near food-handling establishments and cargo storage areas.

Regardless of where the space spray is to be used, make sure that the chemical is authorized to be used in the area to be treated. You can find recommended chemicals and the location of use as space sprays for fly control in Appendix A.

Fly Cords and Resin Strips. The installation of insecticide-impregnated cotton cords at a rate of 30 linear feet of cord per 100 square feet of floor space has provided good fly control in stables for periods varying from 6 weeks to an entire season. The flies rest on the cords and absorb a lethal dose of insecticide through their feet. CDC research has shown that better fly control occurs when the cords are hung vertically (as 15 pieces of cord 2 feet long, or 10 pieces of cord 3 feet long, per 100 square feet of floor space) rather than horizontally (as 30 feet of cord parallel to the floor). Diazinon and parathion are the insecticides of choice in commercially prepared fly cords which have been labeled for installation in milking barns, calf sheds, poultry houses and feed rooms. Dichlorvos-resin strips have been used as residual fumigants in fly control, giving off a lethal dose of dichlorvos vapor for periods as long as 3 to 4 months when used at a rate of one unit per 1000 cubic feet. In Georgia dichlorvos resin strips gave 95 percent reduction of all flies trapped from garbage pits (with a diameter of about 30 inches and 72 inches deep) in a recreational area when installed at a rate of one-half to one unit per pit. Dichlorvos-resin strips have also provided effective control of flies in indoor areas with minimal ventilation when used at a rate of one unit per 1000 cubic feet. They should not be used in rooms where infants, sick, or aged persons are confined, or in areas where food is prepared or served.

Larviciding. Larviciding for the control of domestic flies has never been very successful. One of the real problems is adequate penetration of the breeding media (as garbage or manure) so that the chemical actually comes in contact with the larvae. However, new developments such as the use of juvenile hormone chemicals may make this type of control more productive. Some workers have attempted to alter the chemical makeup of the breeding media so that, although the females lay eggs in it, the larvae do not reach maturity. The traditional example is the addition of borax to manure to retard fly breeding. Such treatment makes the manure unsuitable as fertilizer. Chloride of lime, used to deodorize privies, is a poor larvicide. Some chemicals which have shown promise as larvicides are diazinon (0.5% to 1%), dimethoate (1.0% to 1.25%, and dichlorvos (0.5% to 1.0%). In garbage cans the addition of 2 ounces of paradichlorobenzene every week or two is effective. Small pieces of dichlorvos resin strip placed in special holders in garbage cans have given good control of domestic flies for 2 to 3 months or longer.

Repellents. Repellents are coming into more and more use to (1) keep flies away from animals, and (2) keep flies away from doors of food service establishments. Livestock smears and sprays commonly used contain oil of cloves, safrol, pin oil, camphor, or tabutrex. Diethyltoluamide is an excellent fly repellent for human use and will repel mosquitoes, ticks, and mites as well. Several proprietary materials are available for use as fly repellents around food service establishments, providing they are authorized for this use.

Fly Attractants. Attractants have been used to a limited extent to attract flies to specially treated breeding media. This, however, has been found to have little use in most large control programs. The addition of new synthetic lures to dry organophosphate fly baits offers promise of success in controlling domestic flies and eye gnats. Sticky fly paper, once widely used, has fallen into general disuse as it is unsightly and only serves to attract more flies than would ordinarily be present.

Exercises (626):

1. Match the chemical control measures for flies in column A with the statements in column B.

Column A

______ 1. Residual sprays
______ 2. Fly baits
______ 3. Space sprays
______ 4. Fly cords and resin straps
______ 5. Larviciding
______ 6. Repellents
______ 7. Fly attractants

Column B

a. The installation of insecticide-impregnated cotton cords at a rate of 30 linear feet of cord per 100 square feet of floor space has provided good fly control in stables.

b. The housefly has developed resistance to many of the chlorinated hydrocarbon and organophosphate insecticides, and these treatments are of little value in controlling this species.

c. One of the real problems is adequate penetration of the breeding media.

d. Livestock smears and sprays commonly used contain oil of cloves, safrol, pine oil, camphor, or tabutrex.

e. Dry baits generally contain 1 to 2 percent of the insecticide and an attractant such as sugar.

f. They do not provide a residual deposit of the toxicant and must be repeated periodically.

g. This has been found to have little use in most large control programs.

2. Complete the following statements concerning the chemical control of flies.
   1. For many years, residual sprays were one of the major method of controlling ____________.
   2. For outdoor application, the addition of sugar helps to ____________.
   3. Liquid baits generally contain 0.1 to 0.2 percent of the insecticide and __________ as an ______ ______ dissolved in water.
   4. Dichlorvos strips give off a lethal does of vapors for periods as long as __________ months.
   5. Larviciding for the control of domestic flies has ______________________________.
   6. Several proprietary materials are available for use as fly repellents around ____________.

627. Complete the statements that are provided concerning integrated fly control programs.

Integrated fly control takes the principle of environmental sanitation and supplements it with the use of biological agents and the judicious use of insecticides.

Since most fly control requires the cooperation of the entire base, education is the number one requirement of a good program. It begins with a realization of the problem by responsible individuals, extends through the orientation of officials, and reaches its fruition in the education of all people on the base. Fly surveys, to determine the extent of the problem and to guide the control operations, must be made. Then, efficient and effective control measures must be taken. Additional surveys are used to evaluate the results of the effort and point out where more control measures are necessary.

Once a high degree of fly abatement has been achieved, a continuing program is necessary to maintain the gain. Yet, it is in this area that fly control programs most often fail. When flies are no longer a serious problem, group interest lags, other problems take away the attention of officials, and the flies begin a gradual but certain return. Organized fly control should be incorporated into the regular program of every entomology section.

Exercises (627):

1. The most important element in satisfactory control of domestic flies is a __________ of __________.
2. Since most fly control requires the cooperation of the entire base, education is the ____________ of a good program.
3. Once a high degree of fly abatement has been achieved, a continuing program is necessary to ____________.
4. Organized fly control should be incorporated into the ____________ program of every ____________ section.

CHAPTER 3

Fleas

FLEAS CARRY DISEASE in many parts of the world. They carry the organisms of bubonic plague and fleaborne typhus from rats to humans. In addition, they make insidious attacks on humans and domestic animals. After studying this chapter, you should know the names, characteristics, and controls of important flea species.

3-1. Characteristics and Habits

Since fleas differ in their host preferences, vector ability, and degree of association with human beings, you need to know which species are prevalent in order to judge the possible disease significance and to plan suitable control methods. This section covers the identifying characteristics and the habitats of the important flea species. But first let's study the general characteristics and habits of fleas during each of their developmental stages.

628. Indicate whether given statements pertaining to the general characteristics and habits of fleas are true or false; correct the false statements.

Adults. Fleas are small, wingless insects varying from 1 to 9 millimeters in length, averaging 2 to 4 millimeters. The name of the flea order, "Siphonaptera," refers to their method of feeding through a siphon or tube and to their lack of wings. The flea (fig. 3-1) is compressed laterally with spines directed to the posterior, features which adapt it for moving about between the hairs and feathers of mammals and birds. Most species move about a great deal and remain upon the host only part of the time to obtain a blood meal. The mouthparts consist chiefly of three stylets that are used to penetrate the skin of the host and form a tube for sucking blood. The paired maxillae, acting as cutting organs, enter the skin with the epipharynx. On reaching a small blood vessel, the tip of the epipharynx enters the lumen while the maxillae (which form the salivary canals) remain outside emitting saliva from time to time. Thus, fleas may be characterized as capillary feeders—a fact of importance in transmission of pathogens. Both sexes feed upon blood, and the female requires a blood meal before producing eggs. The long, powerful legs of certain species are adapted for jumping 7 to 8 inches vertically and 14 to 16 inches horizontally.

Most species infest the smaller mammals, such as rodents, rabbits, moles, and bats. Fewer species are parasitic upon larger animals and birds. Most fleas are specific in their host preference, feeding on only one type of host (or closely related species in the same genus), while others have developed an ability to feed upon various hosts. Fleas are very sensitive to extremes of temperatures and humidity. This explains the relative abundance of fleas infesting animals that live in burrows and sheltered nests and the light infestations of fleas on mammals or birds that have no permanent abode or live in nests exposed to the elements. Nests furnish an abundance of organic food for flea larvae leading to a high rate of survival. Fleas infesting burrowing or nocturnal animals tend to have poorly developed eyes, or eyes may be absent. Those infesting animals active during the day are more likely to have well-developed eyes. Some fleas feed at frequent intervals—once a day or more often. They are easily disturbed and seldom complete a meal at one feeding. The human flea continues feeding after the digestive tract is gorged, causing the passage of undigested blood from the anus.

Adults are usually ready to feed in 24 hours after emergence from the cocoon. Mating usually follows the initial blood meal and usually occurs on the host animal. Fleas have a complete metamorphosis as shown in figure 3-2.

Eggs. Eggs are usually deposited among the hairs or feathers of the host or in the nest. They are smooth, spherical to oval, light colored, and large enough to be seen with the naked eye. Since they are not sticky or attached to the host, the eggs drop onto the ground or into the nest or bedding of the host, a factor important in explaining the later high concentration of adult fleas in dog or cat boxes or kennels, and on certain rugs or in portions of a building. A flea does not lay her full quota of eggs at one time, but after blood meals, which are necessary for development of the eggs. Successive matings are not necessary for the fertilization of future eggs, as the sperm cells from the initial mating are stored in the spermatheca of the female and are used as required. The eggs hatch in

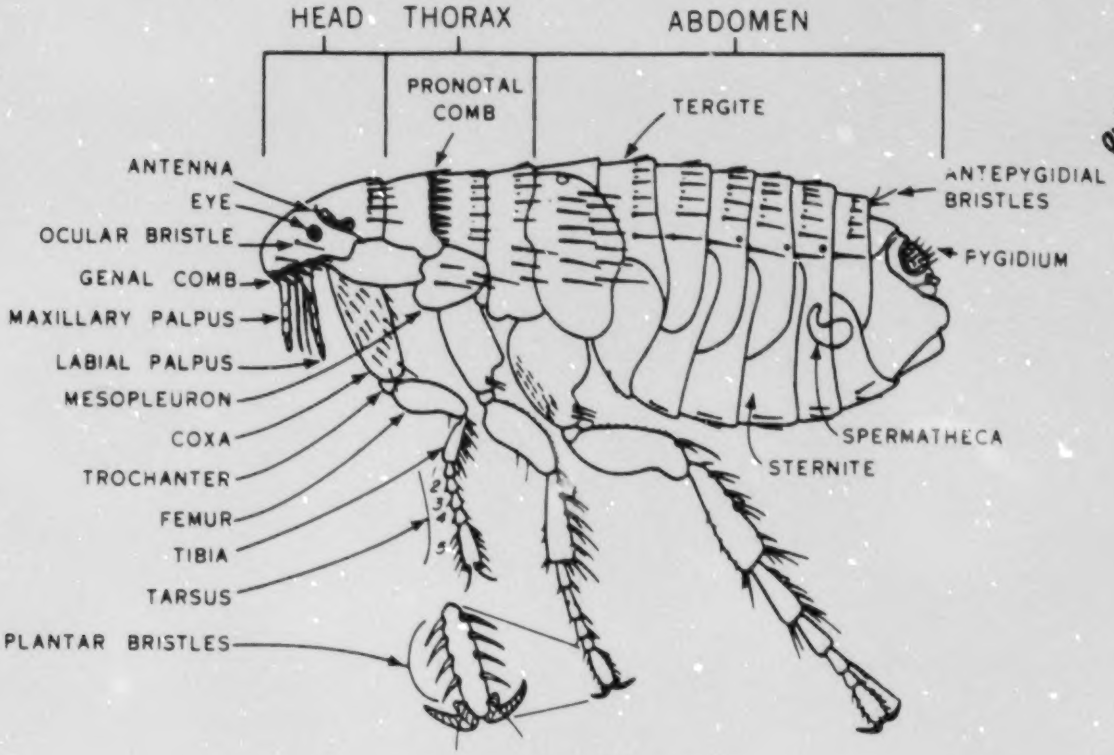
HEAD
THORAX
ABDOMEN
PRONOTAL COMB
TERGITE
ANTENNA
EYE
OCULAR BRISTLE
GENAL COMB
MAXILLARY PALPUS
LABIAL PALPUS
MESOPLEURON
COXA
TROCHANTER
FEMUR
TIBIA
TARSUS
PLANTAR BRISTLES
1
2
3
4
5
ANTEPYGIDIAL BRISTLES
PYGIDIUM
SPERMATHECA
STERNITE

Figure 3-1. Flea diagram.

2 days to several weeks depending upon temperature and humidity.

Larvae. Larvae are small, 13-segmented, wormlike creatures without legs but with chewing mouthparts. The blind, active, whitish flea larvae are often found in the house in floor cracks and rugs, or in kennels, stables, chicken coops, animal burrows, and nests. The larvae feed on all types of organic debris or flea feces, which are composed of more or less digested blood. The three larval stages may be completed in a week to several months.

Pupae. Pupae are usually enclosed in cocoons of finely spun silk encrusted with granules of sand or various types of debris. The pupal stage is usually completed quickly, but the newly formed adult may remain resting within the cocoon from which it emerges on stimulus, depending on the species. Cat fleas emerge in response either to vibrations or carbon dioxide which would indicate proximity to a host. This factor may help explain the large number of hungry cat fleas that attack people returning home after an absence of several weeks. Certain wild rodent fleas emerge in response to an increase in humidity which may occur only once a year in some desert areas.

Exercises (628):

1. Place an X in each blank by a true statement.

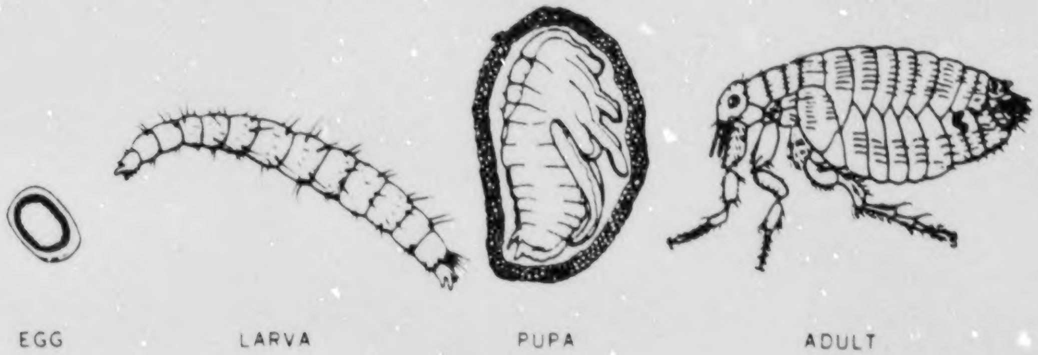
EGG
LARVA
PUPA
ADULT

Figure 3-2. Life cycle of flea.

____ a. Fleas are small, winged insects.
____ b. Most fleas remain on the host only part of the time.
____ c. Fleas are characterized as capillary feeders.
____ d. Fleas are not very sensitive to extremes of temperature and humidity.
____ e. Some fleas feed at frequent intervals.
____ f. Adult fleas are usually ready to feed in 6 hours after emergence from the cocoon.
____ g. A flea lays her full quota of eggs at one time.
____ h. The three larvae stages may be completed in a week to several months.
____ i. The pupal stage is usually completed quickly.

2. Correct any of the false statements in exercise 1.

629. Complete the statements that are provided concerning important aspects of fleas that are used extensively in identification to species.

Most of the important characteristics of fleas are shown and labeled in figure 3-1.

Genal Comb. The presence or absence of genal combs is a quick way to identify certain flea species. If genal combs are present, the number of teeth contained on the genal comb and the position of the comb are other significant identifying characteristics.

Pronotal Comb. The presence or absence of pronotal combs is an important identifying characteristic of certain flea species. Some flea species are identified by the presence of the genal comb and the absence of the pronotal comb, or vice versa, and some may have neither or both.

Other Characteristics. The shape of the head, length of the labial palpi, position of the ocular bristle, number and position of the plantar bristles, and shape of the spermatheca in female specimens are also used extensively in the identification of flea species.

Exercises (629):

1. If a ____________ comb is present, the number of teeth on the genal comb can be determined.
2. The shape of the ____________ , length of the labial ____________ , position of the ____________ bristle, number and position of the plantar ______ ______ , and shape of the ____________ in female specimens are also used extensively in the identification of the flea species.
3. Some fleas are identified by the presence or absence of the ____________ comb and the ______ ______ comb.

630. Match a list of flea species with appropriate descriptive statements.

Oriental Rat Flea. The oriental rat flea *(Xenopsylla cheopis)* is the chief vector of bubonic plague and fleaborne typhus. This insect was first collected in the Nile Valley; hence, the species name "cheopis" for Cheops, the Pharaoh who constructed the Great Pyramid at Giza. The oriental rat flea has been introduced into all sections of the world with Norway and roof rats. The flea is established throughout most of this country, being one of the most abundant rat fleas in the South and in southern California.

The oriental rat fleas do not have a genal or pronotal comb, the ocular bristle is in front of the eye, and the mesopleuron has a vertical rodlike thickening (see Appendix B). Females can be recognized easily by the pigmented spermatheca. This flea is the only species in the United States that has a dark-colored spermatheca. This feature is often of great value in making a quick identification of survey material collected in alcohol or saline water without making a slide preparation of the specimen. The life cycle varies, being completed in as few as 4 to 8 weeks. Adult oriental rat fleas may live for 2 to 4 weeks, depending on the temperature and relative humidity.

Human Flea. The human flea *(Pulex irritans)* is found throughout the warmer parts of the world. It is the most important species attacking humans on the Pacific coast and is often responsible for a dermatitis or allergy due to flea bites. It also causes severe annoyance in the Middle West and South, particularly in homes and surrounding premises. On farms severe infestations of human fleas have often been traced to hogpens, where these insects have persisted for weeks or months after the hogs have been carried off to market. The human flea attacks a wide variety of hosts including swine, dogs, coyotes, prairie dogs, ground squirrels, and burrowing owls. This flea has been collected on these last four hosts in areas remote from human habitations. The human flea has been experimentally infected with plague and shown to be capable of transmitting the bacteria in the laboratory. The human flea can be distinguished from other common United States fleas by the absence of the pronotal and genal combs, the ocular bristle being inserted beneath the eye, and the absence of the internal, rodlike thickening on the mesopleuron (see Appendix B). A second species of Pulex *(Pulex simulans)* occurs in the central and southwestern United States and in Central and South America.

Northern Rat Flea. The northern rat flea *(Nosopsyllus fasciatus)* is commonly found on domestic rats and house mice throughout North America and Europe. This flea is not abundant in areas having an extremely warm climate. It does not readily bite humans and is most commonly found in temperature regions, where plague is not a severe problem. It is the predominant rat flea in the northern United States and is well established in Canada. This species may be of importance in transmission of plague organisms from rat to rat. It has been taken from wild rodents on a few occasions. In 1971, specimens of the northern rat flea were found infected with plague bacteria in the Tacoma area area of Washington. See Appendix B for a description of the northern rat flea.

Dog and Cat Fleas. The dog flea *(Ctenocephalides canis)* and cat flea *(Ctenocephalides felis)* probably occur throughout the United States, although they are less common in the Rocky Mountain States. The cat flea seems to be more abundant and generally distributed than the dog fleas.

The head is about twice as long as high in the cat flea, while it is only about as long as high in the dog flea. In addition, the front margins of the heads of these two species have different shapes. The angle is more acute in the cat flea than in the dog flea. In most cat fleas the first and second teeth of the genal comb are approximately equal in length, while in typical dog fleas the first tooth is shorter than the second (see Appendix B). The dog flea has two stout bristles between the long postmedian and apical bristle on the hind margin of the hind tibia, while the cat flea has only one bristle in this position.

Both species are found commonly in homes, under houses, or in yards, preferring locations where dust and organic debris accumulate. These fleas attack cats, dogs, and a wide variety of other mammals, such as foxes, raccoons, and rats. They are serious pests of humans, particularly during the summer, causing severe bites. Under favorable conditions, a generation of the cat flea requires about 2 to 4 days for the eggs, 8 to 24 days for the larvae, and five to seven days for the pupae to develop.

Chigoe Flea. The Chigoe flea *(Tunga penetrans)* is a small, burrowing flea found in tropical and subtropical regions in North and South America, the West Indies, and Africa. It is not known to have become established in the United States. The flea is unusual in that the female actually burrows into or becomes embedded in the skin of the host. Engorgement with blood and the development of eggs cause great distention of the flea abdomen. People are most frequently attacked between the toes or under the toenails, where the flea may swell to the size of a small pea and cause severe pain. Inflammation and formation of ulcers may result. Secondary infection may cause tetanus or gangrene.

Sticktight Flea. The sticktight flea *(Echidnophaga gallinacea)* is a small species that has no genal or pronotal combs but the front margin of the head is angular. It attaches firmly to its host during the adult stage, often forming ulcers on the head and neck of domestic fowl. The eggs are deposited in these ulcers and, after hatching, the larvae crawl out and drop to the ground to feed upon organic matter. All stages may be found in poultry yards and adjacent buildings. This flea attacks rats, cats, dogs, rabbits, ground squirrels, horses, fowl, and many other animals, including humans. This flea has been found infected with plague and can be infected with fleaborne typhus rickettsia. This flea plays a minor role in disease transmission because the females remain permanently fastened to one host by means of their serrated mandibles.

Exercises (630):
Match column A with column B.

Column A
Identifying Characteristics

_____ 1. Important in transmission of plague organisms from rat to rat
_____ 2. Small, burrowing flea found in tropical regions.
_____ 3. Do not have a genal or pronotal comb and the mesopleuron has vertical rodlike thickening.
_____ 4. Occurs throughout the United States.
_____ 5. Responsible for dermatitis or allergy.
_____ 6. Female remains permanently fastened to the host by means of serrated mandibles.
_____ 7. Females recognized by pigmented spermatheca.
_____ 8. Do not have a genal or pronotal comb or rodlike thickening on mesopleuron.
_____ 9. Not abundant in areas having extremely warm climate.
_____ 10. Found commonly in homes and prefer locations where dust and organic debris accumulates.
_____ 11. Females become embedded in the skin of the host.
_____ 12. Deposits eggs in ulcers.

Column B
Fleas

a. Oriental rat flea
b. Human flea
c. Northern rat flea
d. Dog and cat flea
e. Chigoe flea
f. Sticktight flea

3-2. Surveys and Control Measures

Evaluation surveys are essential operations in the control of fleaborne diseases. There are two types of control: pest flea control, and control of rodent fleas for disease prevention.

631. Complete given statements concerning the purpose and methods of conducting rodent ectoparasite surveys.

Surveys may involve sampling of a population of rats to learn the relative abundance of Norway and roof rats in the locality, particularly animals infected with plague or fleaborne typhus. Another type of survey measures the ectoparasite population of rats to determine whether or not the oriental rat flea is prevalent. It is also possible to determine the incidence of fleaborne typhus in the rodent reservoir by means of complement fixation or Weil-Felix tests of rat blood, and of plague by culturing certain tissues, such as the spleen. The above types of information are generally recorded for each lot of rats trapped.

Survey Methods. The usual survey method for determining the number of parasites per rat and the percentage of rats infested by oriental rat fleas requires the trapping of live rats at numerous points in the survey city. The rats are trapped in #0 steel traps and placed immediately in individual cloth bags to prevent the escape of fleas and other ectoparasites. They are brought to the laboratory in these bags, which are labeled to show the date, trapper, species and sex of rat, locality, and other information. The rats are anesthetized and combed with a fine-toothed comb in order that the parasites may be collected in a large white pan. These parasites are later identified, counted, and recorded along with the rat number and other information on the trapped rat. It is then possible to determine the number of oriental rat fleas per rat and the percentage of rats infested by the fleas.

The ectoparasite survey indicates the degree of infestation by oriental rat fleas and other ectoparasites, and hence the potential danger of transmission of rodentborne disease, should it be present in the rodent population.

Surveys made before and at intervals after dusting programs measure the effectiveness and duration of the control operation. Surveys are made in planning a vector control program in order to determine whether or not dusting operations are necessary. This type of survey plus the information obtained from tabulation of the incidence of disease in humans and domestic rats, furnishes basic information for an epidemiological study of the disease.

Exercises (631):

1. Rats are trapped in #0 ____________ traps and placed in individual cloth ____________ to prevent the escape of ____________ and other estoparasites.
2. The rats are combed with a ____________ comb so that the parasites can be collected in a large white pan.
3. The ectoparasite survey indicates the degree of infestation by ____________ .

632. Complete given statements concerning the methods used in controlling pest fleas on pets and on premises.

Control of Pest Fleas on Pets and Premises. Pest flea control may be divided into two main categories: control of pest fleas on pets, primarily cats and dogs, and control of pest fleas on premises. The principal approach to control is through insecticides. Insecticides for the control of fleas on pets or inside buildings are usually less toxic and are used at a lower concentration than those applied outside buildings.

With cat and dog fleas, reinfestation will occur within a short period of time unless thorough control procedures are carried out. Simultaneous treatment of both hosts and premises gives a much better chance for economical and quick control than either alone. Thus, if a cat or dog is treated to kill a flea infestation, it will soon become heavily infested again unless all nearby flea breeding sites are treated. It is necessary to know the habits of the animal in order that its favorite resting places will be known. A treatment of the infested animal plus a complete coverage of all breeding sites is much more effective than weekly treatments of the animal alone.

Control of pest fleas on pets. Control of cat and dog fleas, the usual species found on pets or in buildings, can be accomplished with a number of insecticides. The insecticides of plant origin, applied as dusts are safe to use on cats, kittens, puppies, dogs, and other domestic animals; however make sure that the presticide is recommented for that use.

All insecticidal dusts should be applied to the fur with a shaker, or by hand, and rubbed in to give a complete treatment. Avoid getting the dust into the eyes, nostrils, and mouth of the animal. Also, avoid making heavy applications to the abdomen as the material will be licked off by the pet. Start the application above the eyes on the head and cover all areas backward to the tail and haunches, being certain to treat thoroughly around the ears and underneath the forelegs. A tablespoon of dust will treat a small animal, while as much as an ounce will be required for a large dog. Frequently, following the application of insecticidal dusts, fleas become extremely active and make cats and dogs most uncomfortable for some time.

Resin collars containing dichlorvos are labeled for use on dogs (except whippets and greyhounds) and on cats (except Persian). They provide protection usually for 2 to 3 months. These resin-dichlorvos collars should be used with care since some animals show individual sensitivity to the insecticide. Cotton webbing collars impregnated with 0.75 to 1.0 percent lindane may be used on either dogs or cats.

A relatively new development in the control of fleas and other ectoparasites on dogs is the use of one of the less toxic organic phosphorous insecticides, ronnel or trichlorofon, as a systemic insecticide. Pills containing ronnel are sold and fed to the animal only by, or on the order of, a licensed veterinarian.

Control of pest fleas on premises. For effective control of fleas, the treatment of the animal should be supplemented by insecticidal applications to the premises. Special attention should be given to the resting places of the animal, where the flea eggs, larvae, pupae and adults are most abundant. Flea infestations may be greatest in dog kennels and bedding rugs, under porches, and similar resting places. Where possible, the animal's bedding should be laundered in hot, soapy water, or burned. A vacuum cleaner may be used to remove accumulations of lint and dust that contain flea larvae and pupae. Then the infested premises may be treated with a residual insecticide such as 2 percent malathion, or 1 percent ronnel, at a rate of about 1 gallon per 1000 square feet of floor surface.

Be sure to read the pesticide label to see if the pesticide can be used for the purpose intended. A number of factors will influence the choice of material and type of formulation to be used for indoor applications, particularly odor, fire hazard, possibility of staining, and use of the treated area.

Dusts may also be used in controlling fleas inside buildings, particularly animal boxes or bedding, basements, and other situations where the whitish discoloration from powders is not objectionable. Dusts are frequently blown under porches, the crawl space under homes, in attics, and garages.

In many places in the United States, especially in the South and West, yard infestations of fleas often are a real problem. Sanitation is just as important in flea control as in other fields of vector control. Animal manure and debris should be removed from pens and yards where fleas may be developing.

For insecticidal treatment of lawns and yards, dusts or suspensions are frequently used in preference to emulsions or solutions. Wettable powders and dusts are safe on shrubbery and grass and have a long residual action, but they leave a light-colored deposit. The dusts are frequently twice as strong as the sprays. Emulsions containing these insecticides may be used in yards if the operator is certain that the emulsions being used will not harm the plants. Some of the auxiliary solvents used in preparing emulsion concentrates will "burn" foliage or grass. The use of solutions on vegetation is even more dangerous since many of the petroleum solvents are known to be phytotoxic. Care should be taken not to release sprays at high pressure close to foliage since this may also damage vegetation. Any soil or lawn areas that require treatment should be very thoroughly soaked.

Exercises (632):

1. Pest flea control may be divided into two main categories: control of pest fleas on __________ ; control of pest fleas on __________ .
2. Cat and dog fleas can be controlled on domestic animals using insecticides of __________ origin applied as __________ .
3. All insecticidal dusts should be applied into the fur with a __________ or by __________ and __________ in to give a complete treatment.
4. A treatment of the infested animal plus a complete coverage of all __________ sites is more effective than a __________ treatment of the animal alone.
5. Resin collars containing __________ are labeled for use on dogs and cats.
6. Pills containing __________ are sold and fed to animals only by a licensed veterinarian.
7. After animal bedding has been thoroughly cleaned, the infested premises may be treated with a residual insecticide such as 2 percent __________ .
8. __________ may be used in controlling fleas inside buildings, where the whitish discoloration from powders in not objectionable.
9. Emulsions may be used in yards if the operator is certain that emulsion do not harm the __________ .

633. Indicate whether given statements pertaining to the control of rodent fleas to prevent diseases are true or false and correct the false statements.

Control of Rodent Fleas For Disease Prevention. Control of rodent fleas for disease prevention may be divided into two main categories: control of rodent fleas in urban areas and control of rodent fleas in rural area. Thoroughness is essential in controlling rodent fleas.

Control of rodent fleas in urban areas. Fleas are the most important vectors of plague and fleaborne typhus. Outbreaks of both diseases have been controlled in the past by rat killing, ratproofing, and improved sanitation, but real progress in the control of these diseases was not achieved until the mid-40's with the advent of DDT and the anticoagulant rodenticides. In the early campaigns, control measures started outside the infested area and worked towards the suspected center of infection. Today, control operations are started at the suspected focus and work outwards.

In controlling an epidemic of plague or fleaborne typhus, the following sequence of control operations has worked in a number of areas:

(1) Surveys to determine the extent and intensity of the problem.

(2) Application of residual insecticides such as malathion, diazinon, or carbaryl to kill the infected fleas, particularly the oriental rat flea.

(3) Use of anticoagulant rodenticides such as warfarin, Pival, or Fumarin.

(4) Rat trapping, poisoning with "one-dose" rodenticides, such as red squill or zinc phosphide, or burrow gassing.

(5) Improved general sanitation to keep rodent populations at the lowest possible level, paying particular attention to refuse storage, collection and disposal, and harborage elimination.

(6) Rodent stoppage or ratproofing.

(7) Continued surveys and maintenance to prevent buildup of disease potentials.

Under the current concept of urban control emphasis is placed on residual insecticides and anticoagulant rodenticides, plus rat trapping, rodentproofing, and improved sanitation.

The application of residual insecticides at the suspected focus of infestation at the start of control activities places emphasis on killing the infected fleas as quickly as possible. The anticoagulant rodenticides are also distributed on the first day because these compounds do not kill rodents until they have eaten these materials for several consecutive days. It is wisest to wait at least 2 or 3 days before rat trapping or area poisoning with "one-shot" poisons, such as red squill or zinc phosphide, so that the rodents wandering about treated areas can pick up the insecticide on their feet or fur and carry it into their burrows to kill the greatest number of fleas in these breeding places. More important, as the rodents are trapped or are killed by rodenticides, any fleas still on the rodents will be killed by the "blanket" of insecticide before they can bite other animals, including man, decreasing the disease hazard.

Personal protection. You may obtain relief from flea attack when going into a heavily infested area by treating ankles and trouser legs with dimethyl phthalate. This will give protection for several hours against cat and dog fleas. Clothing may be impregnated in benzyl benzoate to prevent flea attack. The Department of Defense has recommended the use of M-1960 containing N-butylacentanilide, benzyl benzoate, and 2-butyl-2-ethyl-1, 3-propanediol with Tween 80 as an emulsifier, for clothing treatment—particularly the trousers. More recently, diethyltoluamide, sold commercially as OFF or DEET, has shown great promise as a flea repellent. After an area has been dusted, these materials are no longer necessary. Insecticide dusts prevent biting almost immediately, although 3 to 4 hours may be required for complete mortality of dusted fleas.

Control of fleas aboard aircraft. The possibility of introducing plague-infected fleas into the United States via containerized cargo from plague-endemic areas has led to investigations of suitable chemical control measures. Tests conducted on the use of one-half or one dichlorvos-resin strip in "Conex" shipping containers (approximately 300 cubic feet) filled with simulated cargo gave 98 percent to 100 percent kills of oriental rat fleas on rats exposed for 48 hours at temperatures of 60° F. (15.68° C.) or above. Exposures of 6 hours at temperatures of 78° F. (25.76° C.) to 86° F. (30.24° C.) in empty "Conexes" gave average kills of 90 percent in 24 tests. With a 24-hour exposure at temperatures of 75° F. (24.08° C.) to 83° F. (28.56° C.), complete kills were obtained with one-half or one strip in empty or simulated cargo filled "Conexes." Tests in Florida with dichlorvos indicate that vapor concentrations of 0.25 microgram per liter of air for 3 hours produced complete kills of oriental rat flea.

For the disinfection of unoccupied aircraft, high concentrate micronized dusts of various insecticides were evaluated in cooperative tests by the U.S. Department of Agriculture and the Center for Disease Control. Application of micronized dusts of 64 percent propoxur, 20 percent fenthion, 40 percent Dursban or 26 percent SBP-1382 at a rate of 2 grams of dust per 1000 cubic feet produced complete kills of oriental fleas.

During the period 1945 to 1968, 10 percent DDT dust was the insecticide of choice in controlling fleas during epidemics of plague and fleaborne typhus, both in the United States and overseas. However, in the United States, applications of DDT dust to rodent runways and harborage is now recommended only during epidemics. With the present restrictions on the use of DDT and other chlorinated hydrocarbon insecticides in the United States, and the problem of DDT resistance in many parts of the world including Southeast Asia, other insecticides should be considered for controlling the oriental rat fleas.

General sanitation should be improved as quickly as flea control is achieved. Men working in the area should be vaccinated against plague or murine typhus and wear fleaproof clothing that has been treated with repellents, such as M-1960 or conventional repellents. The more time-consuming work of rodent stoppage should not be started until the danger of contracting these diseases is reduced.

The insecticide dust is applied to rat burrows, holes in floors and walls, and enclosed spaces that may serve for rat harborage. It is especially important to treat spaces between double walls and floors and under merchandise where there are rat entries because the danger of disease spread from rodent to man is most severe in buildings. Apply the dust so that there is no contamination of food with the insecticide, particularly during application or by blowing or tracking.

Dust patches consist of a layer of insecticide dust around a rat hole, entryway, burrow, or along a rat run that is in use. The thickness of the patch should depend upon the amount of rat travel evidenced by the presence of rat droppings and footprints. It may vary from a thin film to a patch 1/4 to 3/8 inch thick. Rat entries should be dusted thoroughly and an area 6 to 8 inches long placed on the narrowest part of the runway. Patches on stairways should completely cover two adjacent stair treads. When parasites of roof rats are to be controlled, dust alternate spaces between rafters on overhead "swings." Rat swing marks are usually detected by their dark and glossy appearance because the rat rubs oil from its fur while swinging beneath rafters or traveling along a plate. Dust patches should be placed near feeding, watering, and harboring places of rats and other locations frequented by these rodents.

Control of rodent fleas in rural areas. The control of wild or commensal rodents (which serve as a reservoir of fleaborne diseases) and of their ectoparasites, is difficult, expensive, time-consuming, and often meets with public apathy or disapproval.

In controlling plague epizootics in the western United States, the application of 2 to 3 ounces of 5 percent carbaryl dust per burrow has given good control of wild rodent fleas, particularly the prairie-dog flea. One treatment usually was sufficient to eliminate fleas totally in a treated area for at least 12 weeks.

Exercises (633):

1. Place an X in front of the true statements.

____ a. Fleas are the most important vectors of plague and fleaborne typhus.

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____ b. You may obtain relief from flea attack when going into a heavily infected area by treating ankles and trouser legs with ronnel.

____ c. To control fleas aboard aircraft dichlorvos-resin strips have been used successfully.

____ d. For the disinfection of unoccupied aircraft use micronized dust of 64 percent propoxur.

____ e. Personnel working in infected areas should be vaccinated against plague or murine typhus.

____ f. The danger of disease spread from rodent to man is most severe in rural areas.

2. Correct any false statements in exercise 1.

CHAPTER 4

Lice, Ticks, and Mites

LICE, TICKS, AND MITES have been with us for centuries. Infestations with lice occur today in the United States and many other countries despite great efforts to maintain high standards of health. Entomology and health personnel are often called upon if infestations include or expose large groups of people, particularly in those areas such as schools, dormitories, hospitals, and child care centers.

Ticks, vicious bloodsucking pests, are important to the Air Force because they can disrupt a mission if they are allowed to contaminate areas and infest people and domestic animals. Low morale, sickness, and sometimes death are the result of increased population of these pests.

Mites often infest foods, stuffed furniture, and mattresses. Some of the larger infestations in buildings result from invasions by rodent mites, bird mites, and clover mites. A number of the mites discussed in this chapter are vectors of organisms that cause diseases which affect people and their animals; others cause dermatitis and allergic reactions in humans.

4-1. Lice

The three sucking lice that infest humans are the body louse, the head louse, and the crab louse. The body louse is the species involved in epidemics of louseborne typhus, trench fever, and relapsing fever, but all three cause pediculosis. This section discusses the medical importance, biology, and control of these lice.

634. Mark given statements pertaining to the general characteristics of lice as true or false and correct the false statements.

Identification and Classification. Sucking lice belong to the order Anoplura. These wingless insects are flattened dorsoventrally (fig. 4-1) from top to bottom like a pancake. Adult lice have mouthparts consisting of three stylets modified for piercing and sucking; the stylets are retracted within the head when not in use. Their legs are short and stout, with a large claw on one or more of the three pair of legs for grasping and holding onto hairs. The eggs of lice differ from those of most other insects because they are attached by cement and possess a distinct cap or operculum. Females are usually larger than males and the tip of the abdomen is notched or bilobed. Males have the tip of the abdomen rounded with the somewhat cigar-shaped genitalia often visible through the body wall.

Development. Lice have three immature (nymphal) stages which resemble the adult stage. Most nymphs differ from adults in having fewer hairs on their bodies, fewer sclerotized plates, and in being sexually undifferentiated. Lice are, therefore, good examples of insects with incomplete or gradual metamorphosis, that is, insects with three stages of life: egg, nymph, and adult (fig. 4-2).

Host. Most sucking lice spend their entire life as ectoparasites on mammals (exceptions are bats, marsupials, certain aquatic mammals, and carnivores exclusive of the dog family). The body louse is a conspicuous and important exception because it rests on clothing except when feeding. Sucking lice occur only on mammals, never on birds, reptiles, or amphibia. Each species of louse generally feeds upon only one species of host animal, one genus, or, more rarely, one group of mammals. In general, closely related groups of mammals appear to be infested by closely related species of lice.

Exercises (634):

1. Place an X in front of the true statements.

____ a. The crab louse is the species involved in the epidemics of louseborne typhus and relapsing fever.

____ b. All three types of sucking lice cause pediculosis.

____ c. Adult lice have mouthparts consisting of three stylets modified for piercing and sucking.

____ d. The eggs of lice are smooth, spherical, and are not sticky.

____ e. Most sucking lice spend their entire life on mammals.

2. Correct any false statements in exercise 1.

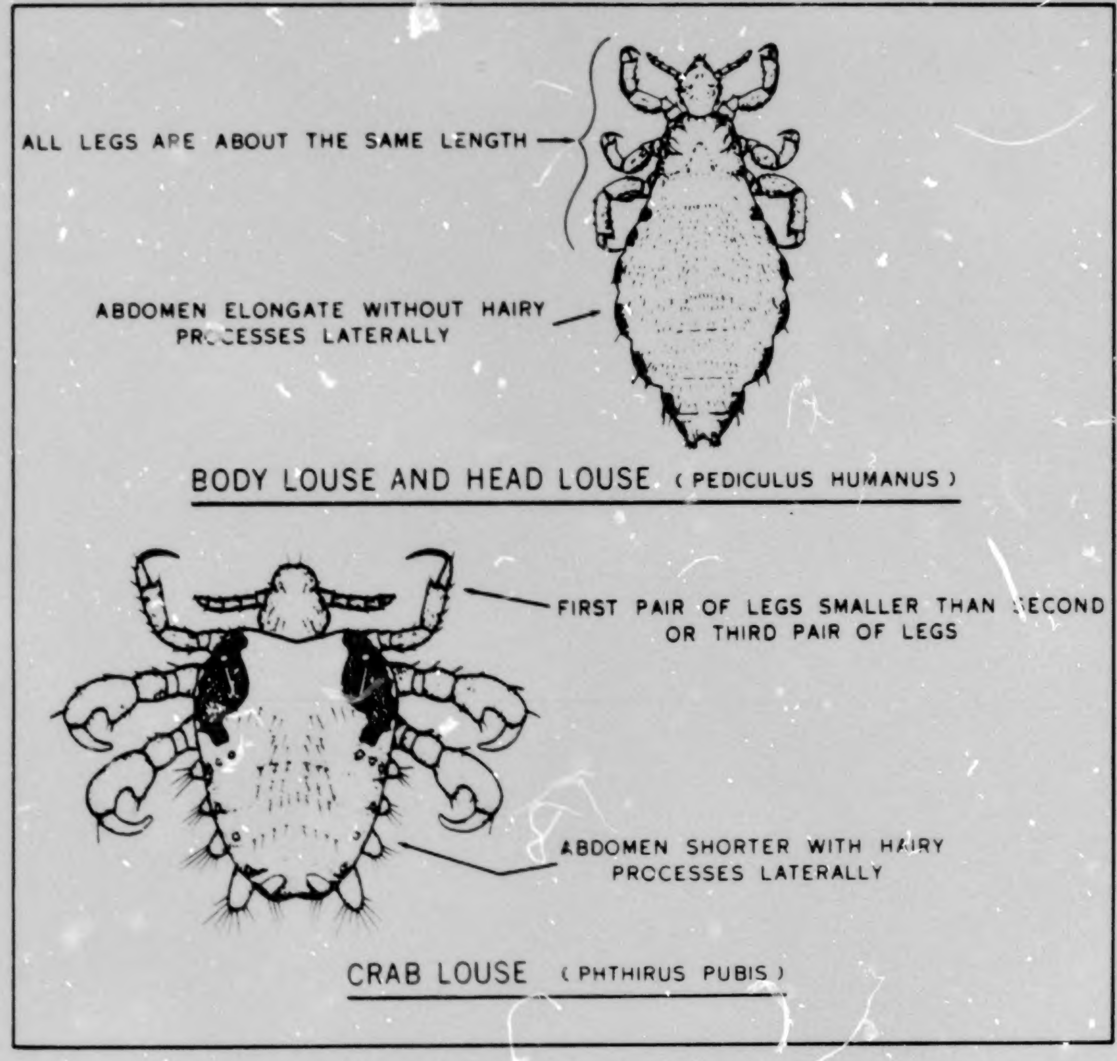
ALL LEGS ARE ABOUT THE SAME LENGTH
ABDOMEN ELONGATE WITHOUT HAIRY PROCESSES LATERALLY
BODY LOUSE AND HEAD LOUSE (PEDICULUS HUMANUS)
FIRST PAIR OF LEGS SMALLER THAN SECOND OR THIRD PAIR OF LEGS
ABDOMEN SHORTER WITH HAIRY PROCESSES LATERALLY
CRAB LOUSE (PHTHIRUS PUBIS)

Figure 4-1. Classification of lice.

635. Identify given statements pertaining to louse characteristics as applying to the head louse, body louse, or both.

The body louse *(Pediculus humanus humanus)* and head louse *(Pediculus humanus capitis)* are very similar to each other physiologically, but they differ morphologically in size, proportion, and color. They also differ biologically in habits, one form living on the head and neck and the other on the body.

Adult Identification. The adult body louse is 2 to 4 millimeters long, greyish white in color, and is generally 10 to 20 percent larger than the head louse.

The head louse is 1 to 2 millimeters long and is greyish white with dark margins.

Habitat. Adults and nymphs of head lice are found in the hair and on the scalp; they tend to be most prevalent on the back of the neck and behind the ears. They are not known to infest eyebrows or eyelashes.

Although as many as 1000 body lice have been removed from the undergarments of one person, it is more typical to find less than 10 lice per person. Most of the lice are on the inner surface of the clothing, next to the skin. Females tend to congregate along seams for egg laying. Some of the adults tend to migrate away from the skin to the outer garments and to other persons. Head and body lice can move fairly rapidly and will pass from host to host, or from host to bedding, by simple contact.

It is difficult to find human lice and crab lice away from humans. Beds occupied every night by unsanitary individuals have more chance of being infested. If unoccupied for several nights, they tend to be free of lice. Head and body lice may be acquired by personal contact and by putting on infested garments. Head lice

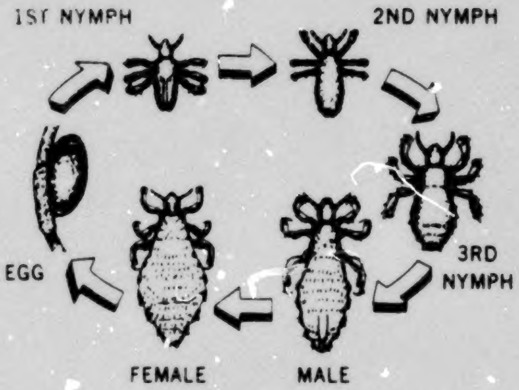

Figure 4-2. Life cycle of head louse.

may be acquired by contact with upholstered chairs and by using infested brushes and combs. Hairs with eggs attached may be blown about. Lice tend to leave a feverish patient and seek other hosts.

Feeding Habits. These lice depend upon human blood as a means of life. They suck blood for long periods of time, but they do not ordinarily become engorged. Some individual lice feed too avidly, causing rupture of their digestive system, and succumb because of their greed. During feeding, dark red feces may be deposited on the skin.

When ready to feed, the louse anchors its mouth to the skin, stabs an opening through the skin, pours saliva into the wound, and pumps blood from the injury into the digestive system by means of the pharyngeal pump.

The body louse remains attached to clothing fibers and bends over to feed while the head louse simply remains attached to body hairs.

Egg Laying. Mating occurs frequently and at any time in the adult's life, from the first 10 hours to old age. Eggs are laid 24 to 48 hours later, depending upon temperature conditions. Eggs are cemented on head hairs by head lice or on the underclothing by body lice. If the human is relatively nude,as in some tropical areas, lice may infest beads and necklaces. Body lice may deposit 9 or 10 eggs per day and a total of 270 to 300 eggs in a lifetime. Head lice are less prolific, depositing about 4 eggs per day for a total of about 88 in a lifetime. The hatching of eggs is greatly reduced or completely prevented by exposure to temperatures above 100° F. (38.08° C.) or lower than 75° F. (24.08° C.).

Nymph Development. After emerging from the egg, the louse nymph molts three times before becoming a sexually mature adult. Therefore, there are three nymphal instars, differing from each other by the increased length of the abdomen as development progresses. The nymphal stages require 8 to 9 days for lice remaining in contact with the human body, but may require 2 to 4 weeks when the clothing is removed at night. If the clothes are worn for several days, all of the lice will usually succomb. The total life cycle of head and body lice may be completed in about 18 days.

Exercises (635):

Match the items in column A with those in column B.

Column A

____ 1. The adult louse is 2 to 4 millimeters long and greyish white.
____ 2. The adult louse is 1 to 2 millimeters long and is greyish white with dark margins.
____ 3. Are not known to infect eyebrows or eyelashes.
____ 4. Can move fairly rapidly from host to host by simple contact.
____ 5. May be acquired by putting on infected garments.
____ 6. Female lays eggs along clothing seams.
____ 7. Tend of leave feverish patients and seek other hosts.
____ 8. May deposit 9 or 10 eggs per day.
____ 9. May deposit 4 eggs per day.
____ 10. The nymphal stage requires 8 to 10 days when remaining in contact with human body.

Column B

a. Head lice
b. Body lice.
c. Both

636. Complete given statements concerning the characteristics of crab lice.

Characteristics of Crab Lice. Crab lice *(Pthirus pubis)* are small (0.8 to 1.0 mm), grayish-white insects with a short abdomen bearing hairy lateral tufts and large second and third pairs of legs which give them a crab-like appearance (fig. 4-1).

These insects are most commonly found on hairs in the pubic areas, but they may be found on hairy areas of the chest or armpits. Infestations of the eyebrows and eyelashes have been reported frequently. Crab lice on the eyebrows feed in a very localized area and cause hemorrhages into the skin which result in a bluish pigment directly above the eyebrows.

The life cycle of the crab louse is similar to that of the head and body lice. The eggs are glued to hairs but are smaller than the body lice eggs.

There are three nymphal stages. In a few specimens that were carefully studied, it took 13 to 17 days for them to become adults. Adult life lasts less than a month. All stages are more sedentary than those of head or body lice. They tend to settle down at one spot, grasping hairs with the legs of both sides of the body, inserting the mouthparts, and taking blood intermittently for many hours at a time. The legs are adapted for grasping large hairs and, in the position adopted, the adult prefers hairs widely spaced (compared with the dense hairs of the head). This may partly explain the distribution of the crab louse which is found most commonly on the hair in the pubic and anal areas. This insect survives only a short time away from the host.

Crab lice are spread chiefly by sexual contact, but they may be acquired by other means, such as infested toilet seats and beds, and by close personal contact.

Many authorities believe that there has been a resurgence in the number of cases of crab louse infestations related to the present worldwide climate of cultural permissiveness.

Exercises (636):

1. Crab lice are small, ____________ insects.
2. These insects are most commonly found on hairs in the ____________ area.
3. The eggs of the crab louse are glued to ____________ but are smaller than the ____________ lice eggs.
4. The adult crab louse prefers hairs ____________ spaced.

637. Provided with statements that pertain to lice controls, identify each of the statements as pertaining to the control of body, head, or crab lice, or all three.

The three kinds of lice that infest humans differ considerably in habits and, therefore, require different methods of control. Because the body louse is the vector of epidemic typhus and other diseases, emphasis has been placed on development of measures for its control.

Control of Body Lice. Lice eggs are laid on the cloth, attached to the fibers; wool cloth is much preferred to other kinds. In looking for infestations, examine the clothing along the seams and folds, especially on the inside of the underwear.

Ordinary laundering with hot water will destroy all stages of lice on infested clothing and bedding. Dry cleaning may be used to destroy lice on wool garments. The solvent used in cleaning is toxic to lice, and the steam used in pressing makes certain that control is complete. Pressing woolens at home is also satisfactory, but special attention must be given to the seams.

Three insecticide powders, 10 percent DDT, 1 percent lindane, and 1 percent malathion, have been extensively used to control body lice. During epidemics of typhus, 10 percent DDT has been the insecticide of choice in many parts of the world. In the United States, where DDT is difficult to obtain and where its use has been largely banned since 1973, or in areas where body lice are resistant to DDT, these insects may be controlled with dusts containing 1 percent lindane, 1 percent malathion, or 0.2 percent pyrethrin, or 0.3 percent allethrin synergized with piperonyl butoxide, providing the pesticide label so states.

These powders are frequently dispensed in 2-ounce sifter-top cans or plastic bags for individual use. The powder should be applied over the inner surface of the underwear and evenly distributed by hand, with special emphasis on the seams and folds. The seams inside the shirt and trousers and socks or stockings should be similarly treated. About one ounce of powder is necessary for one treatment.

Hand-operated dust blowers or motor-driven air compressors with as many as 10 dusting heads have been used for mass treatment of civilian populations, troops, and prisoners of war. The clothing need not be removed. About 2 ounces of the powder is shaken or blown into the clothing through neck openings, up the sleeves, and all around the loosened waist of trousers. In delousing women, an extra amount of insecticide may be introduced around the neck and the application at the waistline omitted.

Control of Head Lice. Head lice spread rapidly through a family and may be transmitted to people throughout a community. They are most abundant in children. In some countries, girls tend to be more heavily infested by both head and body lice than boys.

The eggs, often called "nits," are the easiest stage to discover when inspecting for head lice. They are most commonly attached to the hair, close to the scalp behind the ear.

With schoolboys, men, or prisoners of war, a very close haircut or even shaving of the head to remove the eggs and all later stages is a simple, inexpensive method of controlling head lice. With women and girls, other methods are often used. Both the lice and eggs must be destroyed.

The application of 1 percent lindane or 1 percent malathion dust in pyrophyllite or talc is effective, although it is unsightly. The dust should remain on the scalp 24 hours in order to produce a complete kill. A second treatment 7 to 10 days later will kill all lice that have hatched since the first treatment.

Control of Crab Lice. As with head and body lice, a simple treatment for crab louse control is shaving or cutting the infested hair to remove adults, immature stages, and eggs glued to hairs.

Insecticides, such as the ones recommended in Appendix A for controlling crab lice, or chemicals that are recommended for this use on the pesticide label may be used.

People are very sensitive about infestations of crab lice. A rumor of an infestation in a large office building can do much to disrupt normal operations and cause distress. If these problems are dealt with quickly and firmly, they will soon be forgotten.

Other Lice Control Measures. Frequently, liquid preparations are more acceptable than dusts because the powders are unsightly and suggest that the person is infested with lice. Also, louse powders are not registered for use in California. Shampoos or lotions are available commercially, such as A-200 Pyrinate containing 0.2 percent synergized pyrethins, Cuprex with 31 percent tetrahydronaphthalene and 0.03 percent copper oleate, and Bornate with 5 percent isobornyl thiocyanoacetate and 0.16 percent dioctyl sodium sulfosuccinate.

Two emulsifiable concentrates for controlling all three species of human lice are available by physician's prescription. One contains 1 percent lindane (Kwell). The second (Topocide) is also known as NBIN and contains the following materials by weight: benzyl benzoate—68 percent, DDT—6 percent, benzocaine—12 percent, and Tween 80—14 percent. The present formula does not contain DDT. NBIN is diluted with water before application. Each person is required to take a soap and water bath before treatment. The mixture should be kept out of the eyes. People treated with Kwell should not bathe again for at least 24 hours; those treated with Topocide should wait 48 hours. Benzocaine is a very effective ovicide, thus, the eggs, as well as the active stages, are killed.

The safest and best materials for head louse control are emulsions containing 0.2 percent pyrethrins, 1 percent lindane (Kwell), or 12 percent benzyl benzoate, or insecticide dusts containing 1 percent lindane or 1 percent malathion. The following procedure for using emulsions is safe and easy to follow.

(1) Shampoo and dry the hair thoroughly.

(2) Seat person in chair with head tilted backward and eyes covered with towel.

(3) Apply the emulsion liberally to the hair and scalp with brush and swab. Work against the nap of the hair and touch all hair and the whole scalp.

(4) Comb the hair in the usual manner.

(5) After 10 minutes with the pyrethrin emulsion, or after 24 hours with the lindane or benzyl benzoate emulsion, shampoo the hair.

(6) Dry, comb, and brush hair to remove dead lice and loosened eggs.

Exercises (637):

Match the items in column A with those in column B.

	Column A	*Column B*
____	1. Laundering infested clothing with hot water will destroy all stages of lice.	a. Body lice
		b. Head lice
____	2. One percent lindane powder used to control lice.	c. Crab lice
		d. All three
____	3. Emulsions containing 0.2 percent pyrethrin are the safest and best control of lice.	
____	4. Shaving or cutting the hair is the simplest treatment.	

4-2. Ticks

The material in this section introduces the tick and reviews the characteristics, distribution, and control of the tick. The material will also cover the methods of personal protection, control of animals, and treatment of infested areas.

438. Complete given statements concerning the diseases that ticks spread.

Ticks are known to spread five groups of deadly diseases:

(1) Rickettsial—spotted fever and Q fever.

(2) Bacterial-tularemia.

(3) Spirochetal—relapsing fever.

(4) Viral—Colorado tick fever.

(5) Protozoal—Texas cattle fever.

As you can see, ticks can cause great discomfort to humans. See table 4-1 for the following discussions.

Rocky Mountain Spotted Fever. This is a febrile disease caused by *Rickettsia rickettsii.* In the west, the Rocky Mountain wood tick *(Dermacentor andersoni)* and the rabbit tick *(Haemaphysalis leporispalustris)* spread the disease from animal to animal. *Dermacentor andersoni* is the most important western vector and both male and female of the species are infectious. The American dog tick *(Dermacentor variabilis),* shownin figure 4-3, is the most important vector in the east. Another species, the lone star tick *(Amblyomma americanum)* is probably a vector in parts of the eastern United States and Texas, Oklahoma, and Arkansas.

Dermacentor ticks are well suited as vectors of spotted fever because their larvae and nymphs feed on rodents, and the adults attack man and other large animals. However, transmission of the fever does not occur unless the tick remains attached for more than 2 hours.

Spotted fever has been reported from 46 of the 50 States. This disease is not contracted in Hawaii or Alaska and is seldom reported inland in New England or New York or in the West Central States. The greatest number of cases have been reported from the South Atlantic States, particularly Virginia, Maryland, and North Carolina. Great differences in the virulence of the disease have been reported, the western strain being considered more deadly than the eastern. However, the fatality rate for spotted fever is about as high in the East as it is in the West.

Tularemia. Tularemia or rabbit fever, is a plague-like disease transmitted to humans from rabbits or rodents. This disease has caused heavy losses in sheep. The disease bacteria, *Francisella tularensis* (formerly known as *Pasteurella tularensis),* infects a wide variety of hosts, but is especially prevalent in rabbits. Tularemia is transmitted to these hosts by ticks of the genera *Dermacentor, Amblyomma,* and *Haemaphysalis,* which may transmit the disease organisms to their offspring in the egg and from one stage to another. People acquire the disease by contact with infected rabbits or other animals, the feces of infected ticks, or by tick bites.

Relapsing Fevers. There are two distinct diseases known as relapsing fever, one tickborne, the other louseborne. They show only minor clinical variations and are distinguishable by differences in mode of transmission and geographic distribution. These diseases occur on every continent with the possible exception of Australia and are caused by the spirochetes in the genus *Borrelia.* The epidemic, louseborne type is most frequently due to *Borrelia recurrentis* and the endemic, tickborne type is caused by a number of species of *Borrelia.* Louseborne relapsing fever is not known to occur in the United States at the present time.

TABLE 4-1
TICKBORNE DISEASES IN THE UNITED STATES

Name of Disease	Disease Organism	Type Organism	Tick Vector
Rocky Mountain Spotted fever	Rickettsia rickettsii	rickettsia	Dermacentor Variabilis D. Andersoni D. Occidentalis *** Amblyomma americanum Haemaphysalis leporispalustris *
Tularemia	Pasteurella tularensis	bacterium	D. variabilis D. andersoni H. leporispalustris * Amblyomma americanum
Relapsing Fevers	Borrelia spp.	Spirochete	Ornithodoros hermsi O talaje O Parkeri O. turicate
Colorado Fever	Birus	Virus	D. andersoni
Q fever	Coxiella burnetti	rickettsia	D. andersoni A. americanum Otobius Megnini ***
Tick paralysis	----no organism, toxic secretion ----		D. variabilis
Anaplasmosis **	Anaplasma spp.	protozoan	Many tick species
Cattle tick fever	Babesia bigemina	protozoan	Boophilus annulatus, B. microplus
Bullis fever	Unknown	rickettsia	Amblyomma americanum (?)

* Transmits disease among rabbits.

** Disease of cattle.

*** Found infected in nature but transmission to man has not been reported.

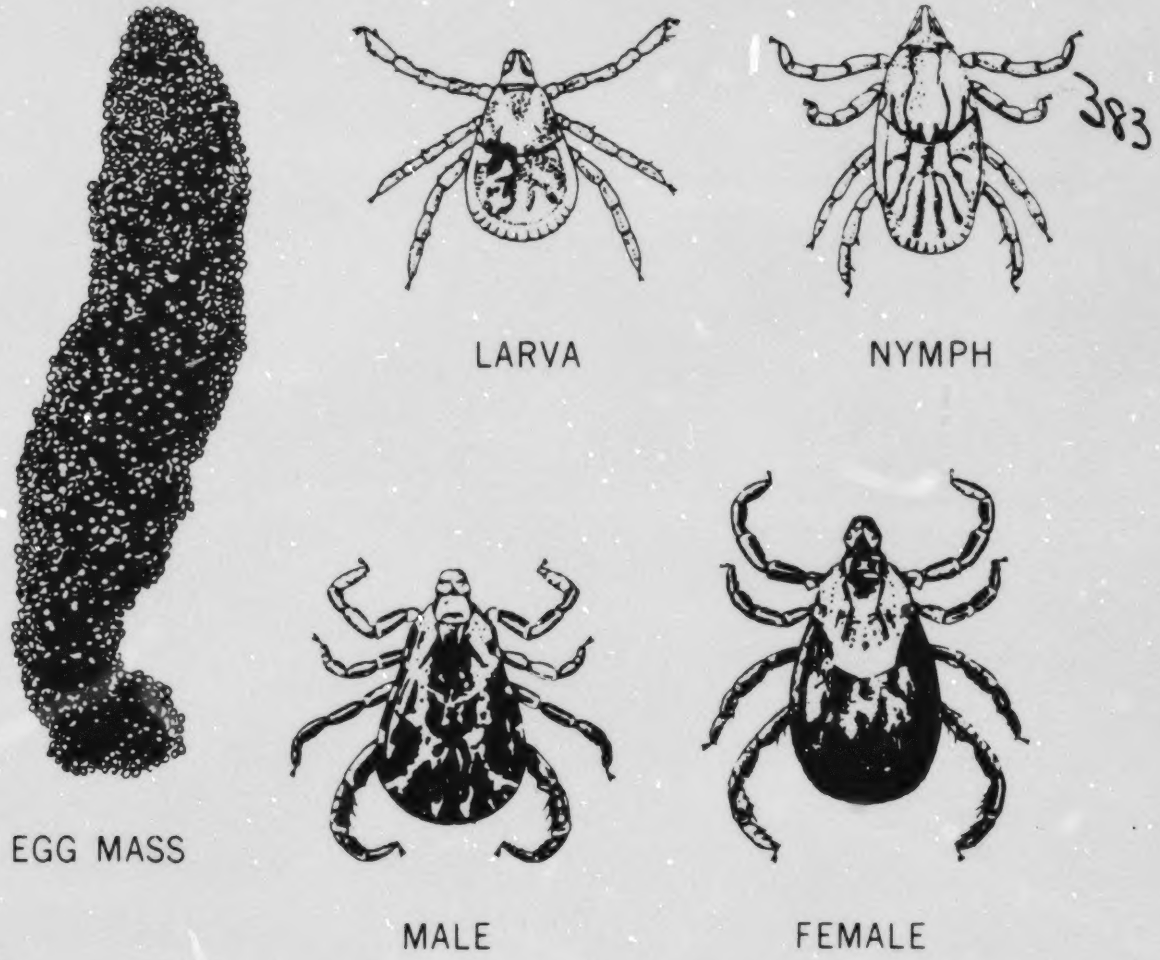

Figure 4-3. Life cycle of American dog tick.

In the United States relapsing fever spirochetes are transmitted by soft ticks of the genus *Ornithodoros* in limited areas of 13 Western States. There are four species which are proven vectors of relapsing fever spirochetes: *Ornithodoros hermsi;* in California, Nevada, Idaho, Oregon, Washington, and Colorado; *Ornithodoros turicata* and *Ornithodoros talaje* in the United States from Florida to California and northward to Kansas, Colorado, and Utah; and *Ornithodoros parkari* in northwestern United States. Ticks remain infective for life and pass the spirochetes to their offspring. Both ticks and their rodent hosts may serve as reservoirs for the disease. Infections of humans are believed to take place by contamination of the wound or skin by tick secretions in some species. *Ornithodoros turicata, Ornithodoros parkeri,* and *Ornithodoros hermsi* definitely infect by the bite.

Colorado Tick Fever. Colorado tick fever is a viral disease of short duration and low mortality, characterized by sudden onset, leukopenia (reduction of white corpuscles in the blood), and absence of the rash usually associated with rickettsial diseases. Human cases occur in Western Canada and in Washington, Oregon, Idaho, Montana, California, Nevada, Utah, Wyoming, Colorado, and South Dakota in an area correlating well with the range of *Dermacentor andersoni.* The virus has been isolated from the Rocky Mountain wood tick and a number of small rodents, particularly ground squirrels. The disease is most prevalent in adult males, but also occurs in women and children.

Cattle Tick Fever. Cattle tick fever (Texas cattle fever) is a deadly disease of cattle caused by tiny protozoans (Babesia bigemina) which destory the red blood cells. This disease is transmitted by the cattle tick *Boophilus annulatus* or the tropical cattle tick *Boophilus microplus.* At one time, the disease occurred in 16 states, ranging from California eastward and from Texas northward to Kentucky and Virginia, killing many cattle. It has been virtually wiped out in the United States by such measures as quarantine and compulsory cattle dipping; however, the disease still causes many cattle losses in the Tropics.

Tick Bite Paralysis. Tick bite paralysis, produced by the engorging female hard tick, is probably caused by a neurotoxic substance in the tick saliva, possibly a foreign protein such as partially digested blood. The symptoms develop about 6 days after the tick becomes attached and while engorgement is well under way. There is a rapid upward progression of flaccid paralysis starting with the feet and legs and extending to the face, tongue, and pharynx, sometimes ending with respiratory failure and death. Tick paralysis is most frequently observed in children under seven years of age and has a high fatality rate. In the United States in 1950, 12 deaths occurred among 94 cases for a 12.7 percent mortality rate. In another study in the Pacific Northwest of the United States, 27 deaths occurred in 238 cases, an 11 percent fatality rate. In North America the wood tick and the American dog tick are the two species that most commonly cause tick paralysis. This disease is most frequently observed in the Northwest and in the southeastern States. The usual site of tick attachment is the scalp, particularly the back of the head. Persons camping and hiking should prevent tick attachment by thorough inspection of the body and garments and the use of tick repellents and protective clothing. Small girls are the most subject to tick paralysis, their long hair can conceal the ticks on the back of the neck. Grown persons are rarely paralyzed. Recovery of patients is rapid following simple removal of the engorging tick and application of a suitable antiseptic. Tick paralysis also occurs in dogs and cattle.

Q Fever. Q fever (Query fever) is a rickettsial disease which has also been known as nine mile fever. The causative organism, *Coxiella burneti,* has caused outbreaks among stockyard workers in Australia and the United States, in laboratory workers, veterinarians, and farmers. The disease has been reported from all continents and in ever-widening localities. The Rocky Mountain wood tick, lone star tick, spinose ear tick, and many other species have been found infected. Tick tissue and feces become massively infected with this rickettsial agent. At least one human case occurred when a hunter "popped" an engorged infected tick in his mouth, the rickettsia easily entering his body through the moist oral tissues. It is suspected that humans may inhale the disease organisms with dust and droplets contaminated with material from infected animals.

Exercises (438):

1. The five groups of deadly diseases transmitted to humans by ticks are (a) ____________ , spotted and Q fever; (b) ____________ , tularemia; (c) ____________ , relapsing fever; (d) viral, ____________ , (e) protozoal, ____________ .
2. Dermacentor ticks are well suited as vectors of ____________ fever because their larvae and nymphs feed on rodents, and the adults attach to people.
3. Tularemia or ____________ fever is a plague-like disease transmitted to humans from rabbits or rodents.
4. Colorado tick fever is a ____________ disease of short duration and low mortality.
5. Cattle tick fever is a deadly disease of cattle caused by tiny ____________ (Babesin bigemina).
6. Tick bite paralysis is probably caused by a neurotoxic substance in the tick ____________ .

639. Identify given statements pertaining to the general characteristics and habits of ticks as being true or false and correct those that are false.

General Characteristics. Ticks have three characteristics which distinguish them from the insects: the head, thorax, and abdomen are fused into one body region; they have no antennae; and in the nymph and adult stages they have four pairs of legs. In true insects, on the other hand, the body is divided into three regions known as head, thorax, and abdomen; they possess a single pair of antennae; and when fully grown they have three pairs of legs.

The order Acarina (ticks and mites) usually differs from other arachnids in that the body is not segmented; the cephalothorax and abdomen are fused to form one body region.

Ticks belong to the suborder Ixodides of the order Acarina. They can be distinguished from other Acarina by two characteristics: the tarsus of the first leg has a conspicuous sensory pore known as Haller's organ, and most species have a prominent, toothed hypostome not found in mites or chiggers.

There are two main groups of ticks: the hard ticks (family Ixodidae) and the soft ticks (family Argasidae). The hard tick is distinguished by a dorsal shield or scutum (fig. 4-4) immediately behind the capitulum (false head). The dorsal shield is small in the female, but in the male it covers the entire dorsal surface. The soft tick has no dorsal shield. Hard ticks also are tapered anteriorly while most soft ticks are blunt.

In the United States hard ticks are much more abundant than soft ticks, cause greater annoyance, and are far more important in the transmission of disease to humans and their animals. An identification key to some common tick species is provided in Appendix B for your use.

Habitats. Hard ticks ordinarily spend much of their life on the ground or on vegetation awaiting hosts. They are most abundant in shrubby areas, especially along paths, and are scarce in deep woodland. Boophilus species pass most of their time on animals, being one-host parasites. Generally, hard ticks feed upon three hosts; frequently, but not always, the larvae and nymphs feed on small mammals or birds and the adults feed on large mammals. *Dermacentor albipictus,* a one-host hard tick, is an exception. The soft ticks feed upon a host only a short time and may be called plural-host ticks.

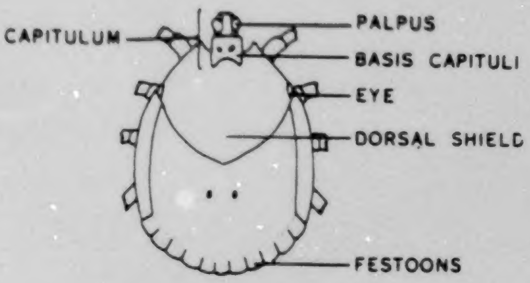

Figure 4-4. Hard tick diagram.

Climatic Factors. Temperature is an important climatic factor affecting tick development. Unfed hard ticks can endure the frigid winter weather in their sheltered retreats, but engorged ticks and eggs are less resistant. The spring and summer heat induces greater tick activity. Hard ticks can endure long submergence in water and are not injured by humid weather. They usually die quickly in a dry situation, whereas soft ticks generally exist in much drier situations.

Longevity. Many hard ticks require a year or two to complete their life cycle but may take longer under unfavorable conditions. Under optimal laboratory conditions, the normal 2-year life cycle of *Dermacentor andersoni* and Amblyomma americanum can be reduced to 2.5 to 3.5 months. Some ticks are long lived. Specimens of *Ornithodoros turicata* have been kept under observation for more than 12 years. *Ornithodoros tholozani,* an Old World species, is known to have a lifespan of 20 to 25 years. Ticks are not easily starved out by rotation of cattle pasturage and other cultural measures.

Feeding. Most ticks parasitize a wide range of host animals. Only a few species show a marked preference for feeding upon one animal species. Ticks feed upon mammals, birds, reptiles, and some amphibians. When feeding, the tick inserts the barbed hypostome (fig. 4-5) into an incision made by its chelicerae. Most species cause no pain to the host, and the unsuspecting human host may be completely surprised when he finds a tick attached on his body. However, some tick species, such as the lone star tick, cause a painful bite. Only females of the hard ticks become greatly distended. *Ornithodoros hermsi* becomes engorged in 15 to 20 minutes while the American dog tick and most other hard ticks require several days.

Transmission of Pathogens. Ticks serve both as mechanical and biological carriers of pathogenic organisms. The mouthparts of ticks feeding on infected animals may become contaminated with the pathogens which are inoculated into healthy animals when the ticks move from one animal to another. This mechanical type of transmission is often called infection through interrupted feeding. In addition, ticks serve as reservoirs of viruses, rickettsiae, bacteria, and protozoa, with transmission of the various pathogens from infected adults through the egg to the following larval, nymphal, and adult stages. This method is often termed "transovarial" or "transstadial" transmission of pathogens. Epidemiologically, this last mechanism is of great importance in maintaining the disease-causing organisms in an area during periods of adverse weather conditions, such as cold winters or hot, dry summers; in establishing endemic foci of such diseases as Colorado tick fever, spotted fever, relapsing fever, tularemia, cattle tick fever, and anaplasmosis; and in maintaining areas with virulent strains of a pathogen. Infected ticks may require several hours of feeding before sufficient parasites are passed into a susceptible host to cause infection. Therefore, campers and people who work in tick-infested areas should check themselves periodically for ticks and remove any they find as soon as possible. The feces of infected ticks often contain pathogenic organisms. Some authorities consider that inhalation of dust, containing the minute fragments of tick feces loaded with Q fever organisms, is an important method of contracting this disease.

Mouthparts. Ticks do not possess a true head, but have a capitulum (fig. 4-4) consisting of a basal portion, the basis capituli, to which the hypostome, chelicerae, and palps are attached. The hypostome typically bears many rows or recurved barbs which anchor the tick to the skin of its host. The chelicerae serve as cutting organs to permit insertion of the hypostome. The palps have four segments or articles, with the fourth segment very small in the hard ticks and approximately equal to the other segments in the soft ticks. The palps do not penetrate the skin of the host. In the hard ticks the mouthparts project from the anterior end of the body, while in the soft ticks they project on the ventral side, hidden dorsally by the body.

Exercises (639):

1. Place an X in front of the true statements.

____ a. Ticks have head, thorax, and abdomen fused into one body region.
____ b. The hard ticks have no dorsal shield.
____ c. There are two main groups of ticks: hard and soft.
____ d. Hard ticks ordinarily spend most of their life on the ground or on vegetation, awaiting hosts.

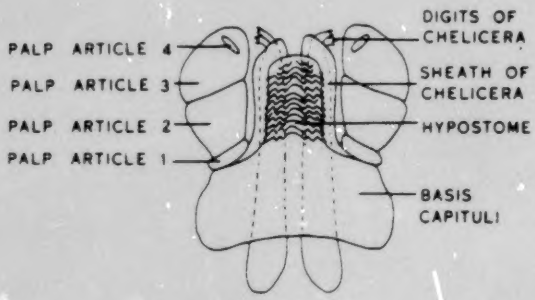

Figure 4-5. Tick mouthparts diagram.

____ e. Engorged ticks can endure frigid weather better than unfed hard ticks.

____ f. Soft ticks generally exist in much drier situations than hard ticks.

____ g. Many hard ticks require a year or two to complete their life cycle.

____ h. Only the male of the hard tick becomes distended when engorged.

____ i. Transstadial transmission of pathogens is accomplished by transmitting from the adult to the egg and through the larval, nymphal, and adult stage.

____ j. One method of contracting diseases is by the inhalation of dusts containing minute fragments of tick feces.

2. Correct the false statements in exercise 1.

640. Complete given statements concerning the developmental stages of ticks.

Ticks have four stages of development: egg, larva, nymph, and adult (fig. 4-3).

Egg Stage. Mating of hard ticks usually occurs while the ticks are on the host animal. Afterwards the female drops to the ground and deposits eggs on or near the earth. Several days are required for development of the eggs. The female hard tick feeds once and lays one large batch of eggs (fig. 4-3), sometimes numbering in the thousands, and dies after oviposition. Most of the soft ticks engorge several times and deposit 20 to 50 eggs in a batch after each blood meal. Eggs hatch in two weeks to several months, depending upon temperature, humidity, and other environmental factors.

Larva Stage. The larvae, or "seed ticks" possess only six legs and are not distinguishable as to sex. Because their chance of attaching to a host is not good, sometimes prolonged fasts are obligatory.

Despite tolerance to starvation, a very high percentage of larvae fail to survive. Some climb on vegetation, waiting for a small rodent to pass within reach. Others actively seek a vertebrate host, being guided by the scent of the animal. After a blood meal, the engorged larvae usually drop to the soil, shed their skins, and emerge as eight-legged nymphs. The larve of one-host ticks remain on the host to molt.

Nymph Stage. The nymph (fig. 4-3) has eight legs like the adult but has no genital opening. This stage also must undergo a critical waiting period for a suitable host. After engorgement, the nymph drops from the host, molts, and becomes an adult. Nymphs may rest for long periods of time before becoming adults. Although the life cycle of some species of hard ticks may be completed in less than 1 year, it may require 2 to 3 years, or longer. Each time a tick leaves its host it risks its survival on the chance that it will find another host. Some species have the advantage of molting on the host. For example, the cattle tick is a one-host tick. Multiple-host ticks are able to exist because of their very great reproductive capacity and their ability to survive for long periods without food.

The hard ticks have only one nymphal instar, the nymph becoming an adult after molting. Soft ticks may have several nymphal instars.

Adult Stage. Typically the nymph molts after engorgement and becomes an adult (fig. 4-3). Sex then is distinguishable for the first time as the female hard tick differs from the male in having a small scutum. The sex of soft ticks may be determined by the shape of the genital opening located between the second pair of legs. In male soft ticks the genital opening is almost circular, while it is oval, definitely broader than long, in female specimens. Unlike mosquitoes, both male and female hard ticks are bloodsuckers and both require several days feeding before copulation. After the male hard tick becomes engorged, he usually copulates with one or more females and then dies. Following copulation, the female tick drops to the ground. The eggs require several days to develop. Then she begins oviposition. After a few more days, her life's mission accomplished, the spent female hard tick also dies. The female soft tick may lay several small batches of eggs but she requires a blood meal before each episode of oviposition.

Exercises (640):

1. Ticks have four stages of development: ________, ________, ________, and ________.
2. Mating of hard ticks usually occurs while the ticks are on the ________.
3. For the eggs to develop requires ________.
4. Eggs hatch in 2 weeks to several months, depending upon ________, ________, and other ________ factors.
5. The nymph has ________ legs like the adult.
6. Nymphs may ________ for ________ periods of time before becoming adults.
7. Despite tolerance to starvation, a very high percentage of larvae ________.
8. The hard tick has ________ nymphal instar.
9. Typically the nymph molts after ________ and becomes an adult.
10. Following copulation the female hard tick ________.

641. Complete given statements concerning tick surveys.

Tick Survey Methods. From tick surveys, you can determine the species present, the degree of tick infestation, whether control is needed, and the results obtained from control efforts.

To determine the infested host and the degree of infestation, you can pick the ticks from the host animals for analysis. To determine the infestation of vegetated areas, use the tick drag method. To conduct this survey with the tick drag, slowly drag it over low vegetation beside roads and paths. After dragging a specified distance, say 50 feet, pick the ticks from the cloth and put them into vials containing 70 to 80 percent alcohol. From this collection, you can adequately determine the species and calculate the approximate degree of infestation.

Exercises (641):

1. From tick surveys, you can determine the ______, the degree of ______, whether ______ ______, and the results obtained from ______.
2. To determine the degree of infestation, you can ______ the ______ from the host animal for analysis.
3. To determine the infestation of vegetated areas, use the ______.

642. Complete given statements pertaining to tick control measures.

You may obtain some degree of protection against ticks by keeping your clothing buttoned, your trouser legs tucked into the tops of your socks, and your shirttail into your trousers. Avoid sitting on the ground or on logs in brush areas, and at intervals inspect your clothing and body for ticks. If you find and remove them before they become attached to your body, you will protect yourself from exposure to tick paralysis and tickborne disease. Clearing and burning brush along paths will reduce the likelihood of tick infestation. In residential areas, closely cut lawns and well-kept yards help control ticks and their small rodent hosts.

If ticks become attached, remove them with a steady pull so that you don't break off their mouthparts and leave them in the wound. There is no certain way to make ticks detach their mouthparts, but a drop of chloroform, carbon tetrachloride, ether, benzene, vaseline, or fingernail polish helps remove them. Always apply an antiseptic to tick bites. If your hands touch the tick, thoroughly wash them with soap and water.

Tick repellents. Many repellents have been tested against ticks, but no general chemical is known. The application of a repellent to exposed skin provides little protection against ticks since they crawl underneath clothing and attack untreated portions of the body. For this reason, treating clothes with repellents is suggested instead of treating the skin. Indalone, diethyltoluamide, dimethyl carbate, dimethyl phthalate, and benzyl benzoate provide up to 90 percent protection. Saturate clothing with a solution or emulsion of the repellent. A 5-percent solution or emulsion will give a deposit of about 2 grams a square foot on denim, ordinary cotton khaki, or light wool. To wet a complete uniform including socks, shirt and trousers thoroughly, about 3 pints are required. After you have saturated your clothing, hang it outdoors to dry. Properly treated clothing will provide good protection against ticks, chiggers, and mosquitoes for several days. You should wash and re-treat clothing thoroughly at weekly intervals or before infrequent outdoor excursions.

Control of Ticks on Domestic Animals. You can free dogs and cats from ticks by using an approved pesticidal dust. Never use diazinon and dieldrin to treat these animals. To clear up infestations, you must treat the pet and the infested area at frequent intervals. At times, it is necessary for you to launder or destroy the animal's bedding if infestation is heavy. If tick infestation is light, you can satisfactorily pick or comb ticks from animals.

Liquid washes may give better penetration of the hair than dust and may be used as an animal dip by veterinarians. Successful control of ticks on dogs by oral use of ronnel has been reported by veterinarians.

Control of Ticks in Buildings. The brown dog tick and the American dog tick come into dwellings on domestic pets. The nonresistant brown dog tick can be effectively controlled by chlorinated hydrocarbon insecticides such as lindane. However, in many areas the dog tick has become resistant to the chlorinated hydrocarbon insecticides; therefore, you must use residual applications of organic phosphorous insecticides, such as those recommended by the pesticide label. If tick infestations are severe, you will have to re-treat both the building and the pet. The pesticides should be employed as spot treatments to baseboards, floor and wall crevices, window frames and other harborage sites. Five-foot-wide band treatments of pesticide granules around foundations may prevent entry of ticks.

Control of Ticks in Vegetated Areas. You can control ticks in vegetated areas by using approved pesticidal dusts, granules, emulsions, or suspensions. The level of control secured is dependent on the adequacy of the coverage. In brushy areas, 50 gallons of spray or 40 pounds of dust per acre are required. Approximately half these amounts are needed on thin cover sites, such as lawns. As certain ticks (e.g., *Dermacentor variabilis)* congregate along roads, paths, and trails, treatment may be restricted to these areas. Treatments with these chemicals usually prevent reinfestation for 30 days or more. Vegetation maintenance such as removal and cutting is very effective at times for controlling ticks and should be accomplished before establishing field encampments.

Control by Removing Hosts. In cases where buildings are severely infested with brown dog ticks which show resistance to insecticides, remove the dog and thoroughly treat the building with an approved insecticide. After removing the dog, dip, dust, or spray him with a recommended insecticide. Other hosts of different tick species are field rodents. You can control these pest hosts by poisoned bait (warfarin, pival, zinc phosphide, strychnine, etc.), trapping, or rodentproofing with masonry, sheet metal, etc.

Exercises (642):

1. If ticks become attached, remove them with a ____________________ so as not to break off their mouthparts.
2. There is no certain way to make ticks detach their mouthparts; however, a drop of ____________, ____________________, ____________________, ____________, ______________, or ____________ helps remove them.
3. For a tick repellent ____________ clothing with a solution of emulsion of the repellent.
4. Insecticides used as repellents are ______________, ____________, ______________, ______________, and ____________________.
5. Never use ____________ and ____________ to treat dogs and cats for tick control.
6. If tick infection is light, you can satisfactorily ____________ or ____________ ticks from animals.
7. In buildings, the nonresistant brown dog ticks can be controlled effectively by chlorinated hydrocarbon insecticides such as ________________.
8. You can control ticks in vegetated areas by using approved pesticidal ____________, ____________, ____________, or ____________.
9. Besides controlling ticks on domestic animals in buildings, in vegetated areas you may also control by ________________.

4-3. Mites

Most species of mites are so small that they are barely visible to the naked eye. Their life cycles are often short, 2 to 3 weeks; thus, mites increase their numbers very rapidly under favorable conditions.

643. Complete given statements concerning mites and the diseases they carry.

Mites are important to humans because they cause or are involved in:

(1) Scabies or mange-like conditions, produced primarily by mange, itch, and follicle mites.

(2) Dermatitis, produced primarily by direct attack of chiggers, bird and rat mites, straw-itch mites, and cheese and flour mites.

(3) Infestation of the lungs, intestine, or urinary passages (by lung mites or certain cheese and flour mite).

(4) Tapeworm infestations of domestic animals and man (beetle mites serve as intermediate hosts for certain tapeworms).

(5) Allergic reactions to mites (entire or fragments thereof) and their excreta may produce conditions similar to asthma in some persons.

(6) Transmission of organisms that cause diseases, primarily those organisms that cause four groups of diseases:

- Viral—as encephalitis (transmitted by certain bird mites).
- Rickettsial—as rickettsialpox (transmitted by the house mouse mite), scrub typhus (transmitted by chiggers in the Pacific area of the Old World), and possibly murine typhus (transmitted by the tropical rat mite).
- Bacterial—as tularemia (transmitted by the tropical rat mite in the laboratory) and epidemic hemorrhagic septicimia (transmitted by the snake mite).
- Filarial—as in the cotton rat (transmitted by the tropical rat mite).

Scabies and Related Mange-like Conditions. Scabies is the most important disease caused by mites. It occurs throughout the world and is caused by the scabies mite, itch mite, and mange mite. Sometimes the mites cause only a mild rash, but often they cause serious skin irritations that lead to secondary infections which produce either conditions similar to impetigo, or severe allergic reactions that prevent persons from sleeping at night. The scabies mites burrow under the skin, leaving open sores or linear burrows containing the mites and their eggs. The first symptom of scabies is itching, especially at night and frequently over much of the body. The signs of scabies are often obscured by scratching, secondary infections, or impetigo.

Itch mites found on domestic animals are almost indistinguishable from human scabies mites. Cases of mange in humans which probably originated from animal infestations are usally of short duration. Mange mites from animals can live on humans but are not able to reproduce and establish infestations.

Scrub Typhus and Hemorrhagic Fever. From the viewpoint of disease transmission, chiggers are probably the most important group of mites because they transmit the rickettsiae that cause scrub typhus (also known as tsutsugamushi disease, Japanese river bottom fever, and Mossman fever). This disease is not found in the United States. However, it has been a disease of importance to American military personnel that have been stationed in the Orient since 1941. Scrub typhus occurs from India, through Southeast Asia, to Japan and Korea. Scrub typhus is transmitted by several species of chiggers.

Chiggers are also suspected of transmitting epidemic hemorrhagic fever. This is a disease, probably caused by a virus, that American troops encountered in Korea. It causes fever and kidney damage and is fatal in about 5 percent of the cases.

Rickettsialpox. In 1946 an outbreak of "atypical chickenpox" in some New York City adults led to the discovery of a previously unknown rickettsial disease, which was named rickettsialpox and transmitted to humans by the house mouse mite from house mice which were the reservoir for the disease. Rickettsailpox has also been reported from Boston, Massachusetts; Philadelphia, Pennsylvania; and Cleveland, Ohio.

The tropical rat mite *(Ornithonyssus bacoti)*, which is far more abundant than the house mouse mite, has been shown capable of transmitting rickettsailpox in the laboratory.

Encephalitis. Encephalitis virus has been found in the chicken mite *(Dermanyssus sylviamum)* and the tropical fowl mite *(Ornithonyssus bursa)*. The role of these mites in vectoring this disease to humans has not been confirmed but it is believed that it is minor if it exists at all.

Dermatitis. Skin inflammations (dermatitis) are caused by several types of mites, primarily chiggers, rodent and bird mites, straw itch mites, and grain or cheese mites. Probably no creatures on earth can cause more torment for their size than chiggers (redbugs). They are found throughout the Tropics and subtropics. Although they are rare in the northeastern United States, they are common in the southern half, in the Mississippi Valley, and the Central Valley of California. They are most abundant in wooded areas, swamps, along roadsides, and particularly where food and shelter for wild rodents and birds are found, as in patches of raspberry and blackberry bushes. The chiggers attach most often in areas where the clothing fits tightly, as at the top of the stockings, the waist area where belts or underwear constrict, and in the armpit area.

Chiggers do not suck blood. The reddish color that is characteristic of some species—hence the name "redbug"— is due to pigments in the mite's tissue, not to blood. Chiggers inject saliva into the host's skin. The reaction of the saliva and host's flesh forms a feeding tube (stylostome). This feeding tube is filled with lymph and partially digested tissue which the mite sucks up as food. In some specimens the stylostome is twice the length of the engorged chigger. Severe cases of chigger dermatitis can itch for a week or longer and be as irritating as acute cases of poison ivy or poison sumac.

Bird mites also cause irritation and annoyance. Chicken mites often feed on people who work either in chicken houses or in live poultry markets. Chicken and bird mites may swarm from pigeon, starling, and English sparrow nests in the eaves or attics along the outside of buildings and crawl through doors or windows, or through openings into the upper portion of buildings, and bite people.

Tropical rat mites *(Ornithonyssus bacoti)* also bite humans. Very often, though not always, persons are bitten when the usual host, the rat, is not available to the mites. Frequently such attacks are associated with death of the rat as the result of trapping, poisoning, or disease; the destruction of rat harborage, or keeping rats out of premises by rat stoppage.

The straw-itch mite *(Pyemotes ventricosus)* is normally a parasite of the larvae of a number of borers. Outbreaks of straw-itch mite dermatitis are usually associated with infested straw and are most common in the midwestern United States. Two of the largest of these outbreaks occurred at the State fairs in Indianapolis, Indiana, among farmers, visitors, and attendants, particularly 4-H students who had show animals bedded on infested straw. The grain and cheese mites are frequently found in tremendous numbers in flour, grain, dried fruits, and cheese, particularly when humidity and temperatures are high. Some of these mites cause dermititis among persons who handle the infested foods.

Infestations of Internal Organs. A number of mites are obligate parasites that live in the respiratory tracts of common laboratory animals, such as dogs, monkeys, and birds. *Pneumonyssoides caninum* has been found in the sinuses and nasal passages of dogs, and *Pneumonyssus simicola* in the lungs of a high percentage of rhesus monkeys used in laboratory research. The canary mite *(Sternostoma tracheacolum)* has been found in the trachea and air sacs of canaries. Other species of nasal mites in the family rhinonyssidae are found in the sinuses of many species of wild and domestic birds.

There are a number of reports of mite infestations of the alimentary canal and of the urinary tracts. Laboratory workers at the Center for Disease Control have examined samples of feces and urine in which mites were found. Most of the mites in the fecal samples examined have been common grain and cheese mites in the families Acaridae, Glycyphagidae, and Tarsonemidae. Mites of these families infest vegetable products and could have been ingested with food. However, it seems likely that some of the fecal samples, and most of the urine samples, had been contaminated by mites that were in the container packing.

Intermediate Hosts of Tapeworms. Many species of beetle mites in the group Oribatei serve as intermediate hosts of at least 13 species of tapeworms. One of these tapeworms, *Bertiella studeri*, has been reported at least 12 times from humans. A well-known tapeworm of sheep, goats, and cattle, *Moniezia expansa*, uses oribatid mites as an intermediate host. The eggs of the tapeworms are ingested by the mites, and during the next several months, the tapeworms develop to the infective cysticeroid stage within the mites. Herbivorous animals feeding on vegetation on which infested mites are crawling easily acquire an infestation, and the tapeworms develop to the adult stage in a period of several weeks. Oribatid mites probably are the intermediate host of the human tapeworm *(Mesocestoides)*.

Allergic Reactions. In recent years, research workers studying the relationship between asthma and house dust have discovered several species of house dust mites (genus *Dermatophagoides*) in dust from houses. The two most important species in the United States seem to be *Dermatophagoides farinae* and *Dermatophagoides pteronyssinus*. They are abundant in dust from mattresses and bedroom floors, but are also found in smaller numbers in other parts of houses.

Annoyance. Many species of mites invade houses and are annoying simply by being there; they do not bite man or transmit diseases. The clover mites *(Bryobia praetiosa)* frequently infest houses in great numbers and annoy householders, particularly in the northern half of the United States. They do not bite man, transmit disease, or damage foodstuffs, but their presence is disturbing. They often swarm by the thousands over outer walls of buildings, particularly those with a sunny exposure, and make their way indoors through cracks and crevices about doors, windows, foundations, and elsewhere. They swarm into houses in the fall, seeking, as do box elder bugs or cluster flies, a place to hibernate. The following spring, they become active again, seeking a way out of the house and back to the growing plants on which they feed. Most clover mite complaints come from new residential areas with well-fertilized lawns or shrubbery next to buildings, where the mites have opportunity to build up large populations. They migrate into homes as cold weather approaches. Usually householders report myriads of "tiny bugs" literally coating the walls as they attempt to swarm into or out of a home. When crushed in linens, curtains, walls, or woodwork, they produce a reddish stain.

Exercises (643):

1. __________ is the most important disease caused by mites.
2. The first symptom of scabies is __________.
3. Mange mites from animals can live on humans but are not able to __________ and establish __________.
4. Chiggers are probably the most important group of mites because they transmit the __________ that cause __________.
5. Chiggers are also suspected of transmitting __________.
6. Rickettsial pox is transmitted to humans by the __________ mite.
7. The __________ and __________ mites are frequently found in tremendous numbers in flour, grain, dried fruits, and cheese.
8. Oribatid mites are probably the intermediate host of the __________.

644. Give the appropriate term for given definitions or phrases pertaining to mites and their suborders.

Mites differ so greatly from one species to another that a short, general description cannot apply to all species. Therefore, our first descriptions are based on various suborders of mites.

General Classification and Description. Mites are members of the class Arachnida and the order Acarina. A typical female mite is usually less than 0.5 mm long with a sack-like body that is often membranous or membranous with hard plates. There is no well-defined segmentation of the body. The head region, known as the capitulum or gnathosome, has cutting structures known as chelicerae which bear two scissor-like blades, called chelae, that are used for biting. Mites undergo four stages of development—egg, larva, nymph, and adult. Six-legged larvae hatch from the eggs, molt, become eight-legged nymphae, and develop into adults.

Description of Mite Suborders. There are three suborders of mites that will be described in this text and each of these suborders contain several important mites.

Suborder Mesostigmata. These mites have a single pair of spiracles lateral to the legs—usually associated with an elongated peritreme (if there is no peritreme, the mite is usually a highly specialized parasite of the respiratory tract of vertebrates). Haller's organ is absent; the hypostome is neither toothed nor developed for piercing. Representatives include such species as the house mouse mite *(Liponyssoides sanguineus),* chicken mite *(Dermanyssus gallinae),* tropical rat mite *(Ornithonyssus bacoti),* tropical fowl mite *(Ornithonyssus bursa),* and northern fowl mite *(Ornithonyssus sylviarum).*

Suborder Trombidiformes. Mites of this suborder have a pair of spiracles on or near the head region (the gnathosome). The chelicerae are usually modified for piercing; the palpi are usually free and highly developed. Haller's organ is absent. The coxae seldom form conspicuous internal projections beneath skin. There are no anal suckers.

Representatives include chiggers *(Trombicula* and allies in the family Trombiculidae), gall mites (family Eriophyiidae), follicle mites *(Demodex* species), straw-itch mites *(Pyemotes ventricosus),* water mites *(Hydracarina),* spider mites *(Tetranychus* and allies), clover mites *(Bryobia praetiosa),* and other mites *(Myobia, Cheyletus, Cheyletiella,* and allies).

Suborder Sarcoptiformes. These mites have no spiracles; a few have a system of tracheae that open through stigmata and porose areas on various parts of the body. There is no Haller's organ. The coxae form conspicuous internal projections beneath the skin of the venter of the body. The mouthparts are usually for chewing; they have strong chelae. The palpi are simple. Anal suckers are often present.

Some representatives are the mange and itch mites *(Sarcoptes, Notoedres, Psoroptes),* house dust mites *(Dermatophagoides),* cheese mites *(Tyrophagus, Caloglphyus, Glycyphagus),* feather mites (Analgesidae), and hair mites (Listrophoridae, *Myocoptes* of mice).

Exercises (644):

1. __________ Mite class.
2. __________ Mite order.
3. __________ Head region of mites.
4. __________ Scissor-like blades used for biting.

5. ______________ Four stages of mite development.

6. ______________ Representatives of this suborder include the house mouse mite and chicken mite.

7. ______________ Representatives include chiggers and water mites.

8. ______________ Representatives include the house dust mites, cheese mites, and feather mites.

645. Match a given list of mites with the appropriate given descriptive phrases.

Itch Mites. The itch mite is a very tiny mite. The females average 0.2 to 0.4 mm in length. The males are somewhat smaller. Each mite is oval and saclike; the body surface is finely wrinkled. The mouthparts contain paired palps and chelicerae, and are located at the anterior end. The anus is located at the posterior end. The dorsal surface has a number of conspicuous blunt spines and many backward-pointing triangular scales. The legs are short and stocky, the two anterior pairs being well separated from the two posterior pairs. Other important identifying characters are given in the key to common mites in Appendix B.

The female burrows beneath the outer layer of skin and lays her eggs in the sinuous tunnels that she excavates. The eggs hatch into larvae that have six legs. The larvae become nymphs (with eight legs), and finally the nymphs become adults. The adults live about a month. Scabies mites occur most commonly in tiny papules, particularly in the webbing between the fingers and in the folds of the skin at the wrists. Positive identification is made by excising a tiny bit of flesh, treating it with 10 percent sodium hydroxode or potassium hydroxide solution, and examining the tissue on a slide with a microscope that has a magnification of 100 diameters or more. The short, stubby legs, the triangular scales, and the peglike spines on the back are easily seen in good preparations.

Chiggers. Chiggers feed on people and other vertebrates only in the larval stage. They have the following developmental stages: egg, deutovum, larva, nymphochrysalis, nymph, imagochrysalis, and adult. On humans they attach in those areas of the body where clothing fits tightly, as at the ankles, waistline, and armpits. As a rule, the larva feeds only once, sucking lymph and partially digested skin tissue (not blood) through its stylostome. The nymphs and adults feed on the eggs or young of various arthropods, such as mosquitoes and springtails, not on humans. Under optimum conditions, the life cycle can be completed in about 50 days. In most of the United States, there are one to three generations a year, depending on latitude. But breeding may be continuous on the gulf coast and in Florida. Chiggers feed on a wide variety of snakes, turtles, birds, and small mammals as well as on humans.

House Mouse Mites. These mites have been found from Utah and Arizona to Boston and Washington. They have been collected by the thousands in apartment houses where house mice were abundant. A few have been collected on rats. The females can be distinguished from most other bloodsucking mites by the presence of two dorsal shields (see Appendix B), a large anterior plate and a small posterior plate. The protonymphs, deutonymphs, and adults suck blood. The house mouse mite is a proven vector of rickettsialpox in Massachusetts, Connecticut, New York, Pennsylvania, and Ohio.

Tropical Rat Mites. The tropical rat mite is often responsible for severe "rat-mite dermatitis" all over the world. Females are usually recognized by their scissor-like chelicerae, the narrow, tapering dorsal and genito-ventral plates and the egg-shaped anal plate (see Appendix B). The protonymphs and females suck blood and are often tremendously distended after feeding. This characteristic is so pronounced that laboratory workers who identify rat ectoparasites often sort the swollen tropical rat mite from among other species without optical aid, and then confirm identification with a microscope.

Chicken Mites. This mite is found throughout most of the world on domestic fowl, pigeons, English sparrows, starlings, and many other birds. The large dorsal and anal plates, short sternal plate, and needlelike chelicerae are important characters for identifying this species (see Appendix B). The chicken mite is one of the most common species that cause human dermatitis in houses, on chicken ranches, and in markets where chickens are sold. Infestations of this mite are often first noticed as the mites crawl about on chicken eggs. Chicken mites are intermittent eaters. To feed they crawl onto the birds at night or when the birds are in their nest. In the daytime, they hide in cracks and crevices in chicken houses, or in floors, walls, and ceilings of buildings in which birds nest.

Northern Fowl Mites. The northern fowl mite is similar to the tropical rat mite, but it has a much shorter sternal plate. This plate has only four setae; the setae on the dorsal plate are quite short. This species is common on domestic fowl, pigeons, sparrow, and starlings. It bites humans readily.

Northern fowl mites overwinter in bird nests (as those of barn swallows and pheobes) and in cracks in buildings. There are several generations each year; the buildup in populations is very rapid. In poultry houses, the mites prefer to stay on birds most of the time, but they have been found on eggs and in litter. On birds, they are often abundant about the vent, tail, and neck; there they suck blood and may form scabs.

Tropical Fowl Mites. This mite is similar to the tropical rat mite, but it has a wider dorsal plate, and is found on domestic and wild birds—seldom on rodents.

Straw-itch mites. This mite is normally a parasite of insects that bore into grain or wood. It sometimes, however, bites humans severely. Unfed females of the species are very small, but after mating, the female becomes greatly englarged. They are then easily visible to the naked eye, resembling a tiny pearl because of the swelling of the body behind the last pair of legs. The first and second pairs of legs are widely separated from the third and fourth pairs. The club-shaped hair between the base of the first and second pairs of legs is an important characteristic in the identification of this mite (see Appendix B). A single female may produce 200 to 300 eggs, which are retained within the body until the offspring have passed through all stages of development. The young, males and females, are produced vivaparously and are sexually mature at birth. Mating takes place soon after.

Grain and Flour Mites. The grain and flour mites (family Acaridae and family Tyroglyphidae) are tiny, and pale gray or yellowish white. They have conspicuous, long hairs. The anterior two pairs of legs are widely separated from the third and fourth pair of legs. These mites feed on a wide variety of organic material and are sometimes very abundant in leaf mold, flour, hair mattresses, and similar substances. They cause grocers' itch and copra itch.

Exercises (645):
Match the name of the mites in column A with their correct description in column B.

Column A

______ 1. Itch mites
______ 2. Chiggers
______ 3. House mouse mite
______ 4. Tropical rat mite
______ 5. Chicken mite
______ 6. Northern fowl mite
______ 7. Tropical fowl mite
______ 8. Straw-itch mite
______ 9. Grain and flour mites

Column B

a. The large dorsal and anal plates, short sternal plate, and needle-like chelicerae are important characters for identifying this specie.
b. This is a very tiny mite. The females average 0.2 to 0.4 mm in length. The males are somewhat smaller.
c. This mite is similar to the tropical rat mite, but has a much shorter sternal plate.
d. These mites are tiny, and pale gray or yellowish white. They have conspicuous, long hairs. The anterior two pairs of legs are widely separated from the third and fourth pair of legs.
e. These mites have the following developmental stages: egg, deutovum, larva, nymphochrysalis, nymph, imagochrysalis, and adult.
f. The females can be distinguished from most other bloodsucking mites by the presence of two dorsal shields, a large anterior plate and a small posterior plate.
g. This mite is similar to the tropical rat mite but has a wider dorsal plate.
h. This mite is normally a parasite of insects that bore into a grain of wood. Unfed females of the specie are very small, but after mating, the female becomes greatly enlarged.
i. This mite is often responsible for severe "rat mite dermatitis" all over the world.

646. Complete given statements concerning the methods used for conducting mite surveys.

Mite Survey Methods. Survey methods vary with the habits of the species being investigated. In chigger-infested areas use black glass plates or cardboard rectangles. Place these vertically and make counts at definite intervals. If chiggers are present, they will climb to the upper edges and congregate there. Test about a dozen spots to locate trouble areas. Use a repellent before you start the survey—otherwise, the chiggers may find you before you find them.

Berlese funnels are frequently used to collect flour and grain mites and other free-ranging species, such as bird mites in nesting material.

Estimates of chigger, bird, and rodent mite population densities can be based on data gathered by:

a. Stunning or killing animal ectoparasites (with ether or chloroform) on dead or trapped animals, and combing (or beating) the parasites from the animal into a white, enameled pan.

b. Picking the mites off with fine forceps, particularly in the case of chiggers that have fastened to an animal.

c. Placing the live host animals in cages that have wire or hardware cloth bottoms so that any mites that drop off after engorging will fall into a pan of water put under the cage. (This procedure is often used to collect chiggers from snakes, turtles, or small rodents).

d. Placing a dead host animal in a glass jar containing water and a detergent. The jar is shaken thoroughly to separate ectoparasites from the animal. The liquid is then poured into a funnel containing filter paper. Any mites will be strained out on the paper.

Exercises (646):
1. Mite survey methods vary with the habits of the species __________________.
2. Black glass plates or cardboard rectangles are used to survey ____________________ areas.
3. Berlese funnels are frequently used to collect _____________ and _____________ mites.

647. Given selected techniques, identify the type of control being used and the mite that is to be controlled; complete given statements pertaining to the chemical methods used for mite control.

Mite Control. Mites can be controlled through environmental methods, including sanitation, mechanical, and construction and maintenance controls, as well as by chemical methods. The method used depends on the mites to be controlled and the circumstances.

Environmental methods. Rat and house mouse mites can be controlled by:

a. Trapping or poisoning rats and mice to eliminate the source of the blood meal essential for nourishment and reproduction of mites.

b. Starving out rodents by storing garbage and food in ratproof containers, rooms or buildings.

c. Keeping rodents out of buildings by rodent stoppage.

Bird mites can be controlled by:

a. Modifying buildings so that birds cannot enter or nest. (Give special attention to louvers, gables, eaves and attics—even though the work calls for screening, carpentry, or masonry.)

b. Trapping or poisoning birds to eliminate the source of blood meals for the mites.

Clover mites can be controlled by:

a. Removing vegetation near houses and pruning shrubs so that they are at least a yard from buildings.

b. Maintaining a strip of bare ground 2 to 3 feet wide around buildings.

Chigger control depends on modifying the environment to permit sunlight and air to circulate freely, thus drying the usual damp habitat of the chigger. These modifications consist of:

a. Keeping lawns and gardens closely cut and edged, and keeping flower beds free of weeds.

b. Eliminating tall weeds and shrubs, particularly blackberry and raspberry bushes, which furnish food and shelter for the bird and rodent hosts of chiggers.

c. Using (in scrub typhus areas) mechanical equipment, such as bulldozers and flamethrowers—thus reducing human contact with the mites—to clear campsites, and using rodent control to eliminate chigger hosts.

Grain and flour mites can usually be controlled by:

a. Rotating food materials to remove the oldest items first (to prevent buildup of infestations).

b. Ventilating to prevent the accumulation of moisture (mites thrive on foods that have a moisture content of 20 percent or more).

c. Eliminating foci or infestations (by vacuum cleaning entire warehouses, with attention to horizontal surfaces such as beams and window ledges).

Chemical methods. Sprays or dusts are used for residual treatment indoors and are frequently used as spot treatments in trouble areas—around windows and doors, at the tops of foundations, around plates and at the ends of joists, on baseboards, and at the edges of floors. Dusts are usually applied at higher concentrations than are sprays. They are placed in voids, in louvers near bird nests, in rodent runways, where the mites *will,* and the children *will not,* normally come into contact with the insecticide.

Residual treatment outdoors has been used for the control of clover mites and chiggers especially, but less commonly on the outside of buildings for control of bird and rat mites.

Fumigation control of flour and grain mites is difficult and should be carried out only by a certified pest control operator. All fumigants are very poisonous and should be used only by qualified operators and *only* according to the directions on the fumigant container's label.

Sulfur has long been used as a chigger repellent. Although the results are variable, it has often given control when dusted into socks, underwear, and outer clothing. Children at summer camps often prefer sulfur to some of the new repellents that have a disagreeable odor.

Many mosquito repellents, such as Indalone, ethyl hexanediol, and dimethyl phthalate will, when applied to the skin, also repel chiggers for 2 to 4 hours. One of the best of the newer repellents is diethyltoluamide.

Most of the good mosquito repellents are also effective when used to treat clothing. The most durable treatment recommended at this time is benzyl benzoate, which will withstand two or three washings. M-1960, which contains 30 percent benzyl benzoate, withstands one or two washings.

Persons who have been in an area infested with chiggers can kill most or all mites that have attached themselves by using a thick lather in a hot bath or shower as soon as possible after exposure. After the bath, an alcohol rubdown will help, particularly on the welts. For temporary relief from itching, compounds such as calomine lotion are available at most drug stores.

Much progress has been made in the treatment of mite infestations on humans and animals. Sulfur ointment, long used in the treatment of scabies, is no longer recommended because it can cause a dermatitis as severe as that caused by the mites. Best results are obtained by taking a hot, soapy bath first, drying the skin thoroughly, and then applying one of the three following remedies to all the body below the neck. Kwell cream, or a lotion containing 1 percent gamma isomer of benzene hexachloride or lindane; Eurax, a salve incorporating 10 percent N-ethyl-O-crotontoluide in vanishing cream; or 12 percent benzyl benzoate. The next day take a bath and change to clean clothing, night clothes, and bedding. Itching may persist for several days and is not a sign of superinfection. It is important that this be understood; overtreatment is common. In perhaps 5 percent of the cases a second course of treatment is necessary after an interval of 1 to 2 weeks.

In treating scabies, thoroughness is essential. Launder every piece of clothing and bedding that may have come into contact with the infested person. If one member of a family or group of persons has scabies, all close contacts should get treatment.

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Exercises (647):

1. Given a technique for controlling mites (column A), state whether the type of control is environmental or chemical, and name the mite that it would control (column B).

Column A		*Column B*	
		Type of Control	*Mite Being Controlled*
1. Starving out rodents by storing garbage and food in ratproof containers, rooms, or buildings.	1.		
2. Using diethyltoluamide.	2.		
3. Maintaining a strip of bare ground 2 to 3 feet wide around buildings.	3.		
4. Rotating food materials to remove the oldest items first.	4.		
5. Keeping lawns and gardens closely cut and edged and keeping flower beds free of weeds.	5.		
6. Treating clothing with benzyl benzoate.	6.		
7. Trapping or poisoning birds to eliminate the source of blood meals for the mites.	7.		

2. Complete the following statements:
   a. Persons who have been in an area infested with chiggers can kill most of all mites that have attached themselves by using a ______ in a ______ or ______ as soon as possible after exposure.
   b. Fumigation control of ______ and ______ mites is difficult and should be carried out only by a ______ pest control operator.
   c. For controlling mites indoors and outdoors, you should apply sprays and/or dusts around ______ and ______, at the tops of ______, around plates at the end of ______, on ______, at the edges of ______.

ANSWERS FOR EXERCISES

CHAPTER 1

Reference:

600 - 1. Two; diseases; organisms.
600 - 2. Host-parasite; host-parasite-vector.
600 - 3. Human; human; living organism.
600 - 4. Measles, pneumonic plague, cholera, typhoid fever, gonorrhea (and) syphillis.
600 - 5. The air.
600 - 6. Water.
600 - 7. Food.
600 - 8. Venereal diseases.
600 - 9. Envenomization; spider bites; bee stings.
600 - 10. Three primary.
600 - 11. Filariasis, malaria, yellow fever, dysentery (and) epidemic typhus.
600 - 12. Viral parasites; Aedes.
600 - 13. Helminth; biologically; Culex.
600 - 14. Protozoan; Anopheles.
600 - 15. Bacterial; mechanically; flies.
600 - 16. Rickettial; body louse.
600 - 17. Rabies, plague, tularemia, spotted fever, murine typhus (and) encephalitis.
600 - 18. Animals; humans; zoonoses.

601 - 1. a. Mechanical—The arthropod serves as a vehicle for the transport of the disease organism. This transport occurs when the organism is carried on the feet, body hairs, mouthparts, or alimentary canal. It is carried from places of filth to human food or the human himself and may be deposited in the feces or by regurgitation.
  b. Biological—The arthropod vector serves as a host for the disease organism. There are three types of biological transmission:
    (1) Propagative—The parasites multiply within the vector but undergo no change in form.
    (2) Cyclo-developmental—The parasites undergo changes in form within the vector but do not multiply.
    (3) Cyclo-propogative—The parasites undergo change in form and also multiply.

601 - 2. a. Feet; body hairs; flies; cockroaches.
  b. Mouthparts; tsetse flies.
  c. Mouthparts; stable flies.
  d. Mechanical.
  e. Host; history.
  f. Rickettsial; tick; mite; eggs.
  g. Larva; nymph; adult.

602 - 1. a. 4, 15.
  b. 6, 7, 13, 14.
  c. 5.
  d. 5, 16.
  e. 8, 17, 18.
  f. 9.
  g. 2.
  h. 9.
  i. 3, 9, 20, 21, 22.
  j. 2, 11, 12.
  k. 25.
  l. 1.
  m. 19.
  n. 10, 23, 24.

602 - 2. a. Plasmodium; anopheles.
  b. Aegypti; yellow fever; Central; South America.
  c. Dengue fever.
  d. Mild; very severe; permanent; nervous system; death.
  e. Serious; 50; 75; fatally.
  f. Mississippi; Wisconsin.
  g. Milder.
  h. Main reservoir.
  i. Animals; reservoirs.
  j. Nematodes; elephantiasis.

603 - 1. Four; egg, larva, pupa (and) adult.
603 - 2. [illegible]; water.
603 - 3. Readily reach the water.
603 - 4. [illegible], 5; flooding does not occur.
603 - 5. Freezing.
603 - 6. Water.
603 - 7. Flowing streams; open waters.
603 - 8. Temperature, light, movement, dissolved gases and salts (and other) living organisms.
603 - 9. Head, thorax (and) abdomen.
603 - 10. Antennae, eyes (and) mouthparts.
603 - 11. Head; abdomen; flattened.
603 - 12. Nine; segments.
603 - 13. In water; very active.
603 - 14. One day; few weeks.
603 - 15. Small, fragile; abdomen; wings; long slender legs.
603 - 16. Spherical; membranous.
603 - 17. Wings; legs.

604 - 1. I; about equal numbers are produced.
604 - 2. C.
604 - 3. I; they remain near the breeding places.
604 - 4. C.
604 - 5. C.
604 - 6. I; most, but not all require a blood meal.
604 - 7. C.
604 - 8. I; various species prefer different hosts.
604 - 9. C.
604 - 10. C.

605 - 1. a.
605 - 2. g.
605 - 3. f.
605 - 4. h.
605 - 5. c.
605 - 6. b.
605 - 7. e.
605 - 8. d.
605 - 9. c.
605 - 10. a.
605 - 11. b, d.

605 - 12. e, d, b.
605 - 13. a.
605 - 14. f.
605 - 15. g.
605 - 16. c.
605 - 17. d.

606 - 1. Malaria.
606 - 2. Houses; humans.
606 - 3. 5; human blood.
606 - 4. Less; unnoticed.
606 - 5. Malaria.
606 - 6. Breeding places.
606 - 7. Dusk; dawn.
606 - 8. Sewage; organic.
606 - 9. February.
606 - 10. Females.
606 - 11. Eggs, malaria.
606 - 12. One-quarter mile.

607 - 1. C.
607 - 2. C.
607 - 3. I; St. Louis encephalitis.
607 - 4. C.
607 - 5. I; in clusters of 50 to 400 eggs.
607 - 6. I; in a day or two; 8 to 10 days required for completion of the larval and pupal stages.
607 - 7. I; some kinds do not require a blood meal.
607 - 8. C.
607 - 9. I; they use almost all types of water.
607 - 10. C.
607 - 11. I; birds are their preferred host.
607 - 12. C.

608 - 1. Three.
608 - 2. Biters; pests.
608 - 3. Larval; pupal.
608 - 4. Surface.
608 - 5. Virus; Eastern encephalitis.
608 - 6. Several months.
608 - 7. The next spring.
608 - 8. Evening; early part of the night.
608 - 9. Light trap collections.
608 - 10. Tropical; Florida; South Texas.
608 - 11. Venezuelan equine encephalitis.
608 - 12. Water lettuce.

609 - 1. f.
609 - 2. c.
609 - 3. a.
609 - 4. b.
609 - 5. d.
609 - 6. g.
609 - 7. e.
609 - 8. d.
609 - 9. f.
609 - 10. b.
609 - 11. a.
609 - 12. c.
609 - 13. g.

610 - 1. a. Planning, operation (and) evaluation.
b. The incidence of.
c. Manpower, materials (and) equipment; justification.
d. Simple; inexpensive.
e. Populations.
f. Domestic animal.
g. Throughout the test.
h. Regular; time of day.
i. West Indies; South America.
j. Sleeping humans.
k. Culex tarsalis.
l. Grass; vegetation.
m. Normally.
n. Dawn; light intensity; humidity.
o. Competing light sources.
p. Light.

610 - 2. a. 3.
b. 1, 16 (depending on species and preferred host).
c. 1, 16 (depending on species and type of bait used).
d. 1, 4, 6, 7.
e. 1, 6, 7, 11, 12, 13, 14, 15, 16.
f. 3, 5, 8, 9, 10.
g. 1, 16 (depending on species and preferred host).
h. 2 (plus some species of Aedes).
i. 2 (plus some species of Aedes).

611 - 1. a. Aquatic habitats.
b. Breeding sites; sampling stations.
c. Larvae per square foot.
d. Spoons; pipettes; widemouthed.
e. 95; 70.
f. Dive to the bottom.
g. Dips; larvae.
h. 1; 2.
i. Certain species.

611 - 2. a. 2, 4, 6, 7, 9.
b. 3.
c. 3.
d. 1.
e. 5, 8.

612 - 1. Fish.
612 - 2. Cisterns, water tanks, garden pools (and) marshes.
612 - 3. *Aedes aegypti* and *albopictus*.
612 - 4. Light-requiring.
612 - 5. Permanent; control.
612 - 6. Removal; vegetation.
612 - 7. Chemicals.
612 - 8. Air currents and spotty application; leaves.
612 - 9. Powders; prehatch; mosquito larvae.
612 - 10. Anopheline; culicine; pupae.
612 - 11. Irrigated waters.
612 - 12. Ultra-low-volume.
612 - 13. Eggs, larvae, (and) pupae.
612 - 14. Toxic effect; suffocation.

613 - 1. Ocean; corrosive action; salt sprays.
613 - 2. 16 x 20; 16 x 23.
613 - 3. Outward; automatic closing.
613 - 4. Mosquito bar; temporary; Tropics.
613 - 5. Net; killed by hand.
613 - 6. Humans; directions.
613 - 7. Late afternoon; early evening; at night; early morning; calm.
613 - 8. 5.
613 - 9. 40.
613 - 10. Little; nonthermal.
613 - 11. Rapidly.
613 - 12. Temporary.
613 - 13. Knockdown; residual.
613 - 14. Film; weeks; months.

CHAPTER 2

614 - 1. Not only do flies annoy and bite humans, but they spread and create disease and destroy agricultural products.
614 - 2. On their mouthparts, through their vomitus, on their body hairs, on the sticky pads of their feet, and through the intestinal tract by means of fly feces.
614 - 3. Any six of the following: bacillary dysentery, infantile diarrhea, typhoid fever, paratyphoid fever, cholera, amoebic dysentery, giardiasis, and pinworm, roundworm, and tapeworm infections.
614 - 4. Intestinal myiasis.

615 - 1. C.

615 - 2. I; different species have mouthparts adapted for different activities.
615 - 3. C.
615 - 4. I; the wings (straight, curved, or angled) are used in identification.
615 - 5. I; four stages (egg, larvae, pupa, and adult).
615 - 6. C.
615 - 7. C.

616 - 1. Domestic; association.
616 - 2. Homes; restraurants.
616 - 3. 8, 20.
616 - 4. 4; 20.
616 - 5. Five; six; 500.
616 - 6. Pupa; food.
616 - 7. Warm; moist; organic.
616 - 8. Feces; organic.
616 - 9. Wide variety; balanced diet.
616 - 10. 48.
616 - 11. Habitual resting places.
616 - 12. 4; 6; 20.
616 - 13. Food; water; temperature.
616 - 14. 45° F (7.28° C.).
616 - 15. 32° F. (0° C.); 112° F. (44.80° C.).
616 - 16. High.
616 - 17. Toward light.
616 - 18. Air currents; extremely windy.
616 - 19. Fungi, bacteria, protozoa, roundworms, arthropods, amphibians, reptiles, birds (and certain) mammals.

617 - 1. c.
617 - 2. b.
617 - 3. e.
617 - 4. d.
617 - 5. a.

618 - 1. Three; thorax; checkerboard; abdomen; reddish brown.
618 - 2. Meats; animal carcasses.
618 - 3. Living larvae.
618 - 4. Humans; mink; fox.

619 - 1. 1. b.
  2. d.
  3. e.
  4. a.
  5. c.
619 - 2. 1. Causing them to swell; with maggots.
  2. Disease organisms; houseflies.
  3. 15 to 20.
  4. Four, eight.
  5. 6 to 10.
  6. Animals; humans; Latin America.

620 - 1. South; Central; Mexico.
620 - 2. Vector; insect; arachnid.
620 - 3. Myiasis, human eye.
620 - 4. Tumorous swellings; backs.
620 - 5. Alimentary, horses; asses.

621 - 1. 1. g.
  2. c.
  3. j.
  4. k.
  5. a.
  6. d.
  7. m.
  8. i.
  9. h.
  10. l.
  11. b.
  12. f.
  13. e.
621 - 2. 1. Water reservoirs.
  2. Reduced.
  3. Blue tongue in sheep.
  4. Bathroom; kitchen.
  5. Bloodsucking.
  6. Long legs.
  7. Spurs; hind tibiae.
  8. Mechanically; intestinal myiasis.

622 - 1. Larval surveys.
622 - 2. Adult.
622 - 3. Baited trap; cone trap.
622 - 4. Bacteriological; virological.
622 - 5. Fly populations.
622 - 6. Fly grill.
622 - 7. Environmental sanitation.

623 - 1. Limited; physical; biological.
623 - 2. Reproduction; mortality.
623 - 3. Food, water, (and) shelter.
623 - 4. Parasites; predators.

624 - 1. True.
624 - 2. False.
624 - 3. True.
624 - 4. False.
624 - 5. True.
624 - 6. True.

625 - 1. Environmental sanitation.
625 - 2. Effective domestic fly control.
625 - 3. Prevent damage.
625 - 4. 12 to 24.
625 - 5. Garbage and refuse.
625 - 6. Compacting; 6.

626 - 1. 1. b.
  2. e.
  3. f.
  4. a.
  5. c.
  6. d.
  7. g.
626 - 2. 1. Houseflies.
  2. Prolong maximum effectiveness.
  3. 10 sugar; attractant.
  4. 3 to 4.
  5. Never been very successful.
  6. Food service establishments.

627 - 1. High level; environmental sanitation.
627 - 2. Number one requirement.
627 - 3. Maintain the gain.
627 - 4. Regular; entomology.

CHAPTER 3

628 - 1. Mark b, c, e, h, i with an X.
628 - 2. a. Change winged to wingless.
  d. Delete the word "not."
  f. Change 6 to 24.
  g. Change lay to "does not lay."

629 - 1. Genal.
629 - 2. Head; palpi; ocular; bristles; spermatheca.
629 - 3. Genal; pronotal.

630 - 1. c.
630 - 2. e.
630 - 3. a.
630 - 4. d.
630 - 5. b.
630 - 6. i.
630 - 7. a.
630 - 8. b.
630 - 9. c.
630 - 10. d.

630 - 11. e.
630 - 12. f.

631 - 1. Steel; bags; fleas.
631 - 2. Fine-toothed; pan.
631 - 3. Oriental rat fleas.

632 - 1. Pets; premises.
632 - 2. Plant; dusts.
632 - 3. Shaker; hand; rubbed.
632 - 4. Breeding; weekly.
632 - 5. Dichlorvos.
632 - 6. Ronnel.
632 - 7. Malathion.
632 - 8. Dusts.
632 - 9. Plants.

633 - 1. True a, c, d, e.
633 - 2. b. Change ronnel to dimethyl phthalate.
f. Change rural areas to buildings.

CHAPTER 4

634 - 1. True b, c, e.
634 - 2. a. Change crab to body.
d. Lice eggs are attached by cement.

635 - 1. b.
635 - 2. a.
635 - 3. a.
635 - 4. c.
635 - 5. c.
635 - 6. b.
635 - 7. c.
635 - 8. b.
635 - 9. a.
635 - 10. c.

636 - 1. Greyish-white.
636 - 2. Pubic.
636 - 3. Hairs; body.
636 - 4. Widely.

637 - 1. a.
637 - 2. d.
637 - 3. b.
637 - 4. d.

638 - 1. Rickettsial; bacterial; spirochetal; Colorado tick fever; Texas cattle fever.
638 - 2. Spotted.
638 - 3. Rabbit.
638 - 4. Viral.
638 - 5. Protozoans.
638 - 6. Saliva.

639 - 1. a, c, d, f, g, i, j are true.
639 - 2. b. Change hard tick to soft tick.
e. Change interchange engored and unfed.
h. Change male to female.

640 - 1. Egg, larva, nymph (and) adult.
640 - 2. Host animal.
640 - 3. Several days.
640 - 4. Temperature, humidity (and other) environmental.
640 - 5. Eight.
640 - 6. Rest; long.
640 - 7. Fail to survive.
640 - 8. Only one.
640 - 9. Engorgement.
640 - 10. Drops to the ground.

641 - 1. Species present; tick infestation; control is needed, control efforts.
641 - 2. Pick; ticks.
641 - 3. Tick drag method.

642 - 1. Steady pull.
642 - 2. Chloroform, carbon tetrachloride, ether, benzene, vaseline (or) fingernail polish.
642 - 3. Saturate.
642 - 4. Indalone, diethylfoluamide, dimethyl carbate, dimethyl phthalate (and) benzyl benzoate.
642 - 5. Diazinon; dieldrin.
642 - 6. Pick; comb.
642 - 7. Lindane.
642 - 8. Dusts, granules, emulsions (or) suspensions.
642 - 9. Removing hosts.

643 - 1. Scabies.
643 - 2. Itching.
643 - 3. Reproduce; infestations.
643 - 4. Rickettsiae; scrub typhus.
643 - 5. Epidemic hemorrhagic fever.
643 - 6. House mouse.
643 - 7. Grain; cheese.
643 - 8. Human tapeworm.

644 - 1. Arachnida.
644 - 2. Acarina.
644 - 3. Capitulum or gnathosome.
644 - 4. Chelae.
644 - 5. Egg, larva, nymph, and adult.
644 - 6. Mesostigmata.
644 - 7. Trombidiformes.
644 - 8. Sarcoptiformes.

645 - 1. b.
645 - 2. e.
645 - 3. f.
645 - 4. i.
645 - 5. a.
645 - 6. c.
645 - 7. [illegible]
645 - 8. h.
645 - 9. d.

646 - 1. Being investigated.
646 - 2. Chigger-infested.
646 - 3. Flour; grain.

647 - 1.

	Type of Control	*Mite being Controlled*
1.	Environmental.	Rat and house mouse mite.
2.	Chemical.	Repel chiggers.
3.	Environmental.	Clover mite.
4.	Environmental.	Grain and flour mites.
5.	Environmental.	Chiggers.
6.	Chemical.	Mosquito.
7.	Environmental.	Bird mites.

647 - 2. a. Thick lather; hot bath; shower.
b. Flour; grain; certified.
c. Windows; doors; foundations; joists; baseboards; floors.

S T O P - 1. MATCH ANSWER SHEET TO THIS EXERCISE NUMBER.
2. USE NUMBER 2 PENCIL ONLY.

EXTENSION COURSE INSTITUTE
VOLUME REVIEW EXERCISE
56650 04 21
DISEASE VECTORS AND PESTS OF DOMESTIC ANIMALS

Carefully read the following:

DO's:

1. Check the "course," "volume," and "form" numbers from the answer sheet address tab against the "VRE answer sheet identification number" in the righthand column of the shipping list. If numbers do not match, take action to return the answer sheet and the shipping list to ECI immediately with a note of explanation.
2. Note that item numbers on answer sheet are sequential in each column.
3. Use a medium sharp #2 black lead pencil for marking answer sheet.
4. Write the correct answer in the margin at the left of the item. (When you review for the course examination, you can cover your answers with a strip of paper and then check your review answers against your original choices.) After you are sure of your answers, transfer them to the answer sheet. If you have to change an answer on the answer sheet, be sure that the erasure is complete. Use a clean eraser. But try to avoid any erasure on on the answer sheet if at all possible.
5. Take action to return entire answer sheet to ECI.
6. Keep Volume Review Exercise booklet for review and reference.
7. If mandatorily enrolled student, process questions or comments through your unit trainer or OJT supervisor. If voluntarily enrolled student, send questions or comments to ECI on ECI Form 17.

DON'Ts:

1. Don't use answer sheets other than one furnished specifically for each review exercise.
2. Don't mark on the answer sheet except to fill in marking blocks. Double marks or excessive markings which overflow marking blocks will register as errors.
3. Don't fold, spindle, staple, tape, or mutilate the answer sheet.
4. Don't use ink or any marking other than a #2 black lead pencil.

NOTE: NUMBERED LEARNING OBJECTIVE REFERENCES ARE USED ON THE VOLUME REVIEW EXERCISE. In parenthesis after each item number on the VRE is the Learning Objective Number where the answer to that item can be located. When answering the items on the VRE, refer to the Learning Objectives indicated by these Numbers. The VRE results will be sent to you on a postcard which will list the actual VRE items you missed. Go to the VRE booklet and locate the Learning Objective Numbers for the items missed. Go to the text and carefully review the areas covered by these references. Review the entire VRE again before you take the closed-book Course Examination.

MULTIPLE CHOICE

1. (600) How many basic cycles are involved in the transmission of diseases to human by living organisms?

   a. 2.
   b. 3.
   c. 4.
   d. 5.

2. (600) Which of the following common diseases would most likely be spread by the air?

   a. Pneumonic plague.
   b. Typhoid fever.
   c. Cholera.
   d. Gonorrhea.

3. (600) Which of the following would be classed as a host-parasite-vector cycle disease?

   a. Malaria.
   b. Pneumonic plaque.
   c. Typhoid fever.
   d. Cholera.

4. (601) Which of the following would be a true statement about the mechanical transmission of vector-borne diseases?

   a. During transmission the parasite changes significantly.
   b. During transmission the parasite multiplies significantly.
   c. As a mechanical transmitter, the arthropod is simply a vehicle which transports the parasite.
   d. As a mechanical transmitter, the arthropod is essential in the life history of the parasite.

5. (601) Which arthropod is probably the most loathsome mechanical transmitter of disease?

   a. Mosquito.
   b. Deer fly.
   c. Housefly.
   d. Cockroach.

6. (601) In biological transmission of disease the term cycle-propagative refer to the condition in which

   a. the parasites undergo no change in form within the vector.
   b. the parasites multiply within the vector but undergo no change in forms.
   c. the parasites neither multiply nor undergo changes of form within the vector.
   d. the parasites undergo change in form and also multiply within the vector.

7. (602) What genera is the vector carrier of yellow fever?

   a. Aedes.
   b. Astec.
   c. Culex.
   d. Anopheles.

8. (602) Which of the following species of mosquitoes transmits malaria?

a. The aedes alarki. c. The anopheles culex.
b. The aedes aegypti. d. The anopheles freeborni.

9. (602) Filariasic disease is transmitted from person to person by various species of

a. rats. c. roaches.
b. flies. d. mosquitoes.

10. (603) How many distinct stages do mosquitoes have in their life history?

a. 2. c. 4.
b. 3. d. 5.

11. (603) The adult mosquito has how many wings and legs?

a. One pair of wings-three pairs of legs.
b. One pair of wings-two pairs of legs.
c. Two pairs of wings-one pair of legs.
d. Two pairs of wings-two pairs of legs.

12. (603) Which statement best describes the eyes of an adult mosquito?

a. One large eye containing many eyes.
b. One pair of large compound eyes.
c. One pair of normal eyes.
d. Two pairs of normal eyes.

13. (604) Which one of the following statements about adult mosquitoes is correct?

a. Only the female bites.
b. The male lives longer than the female.
c. The male travels further than the female.
d. More females are produced than males.

14. (604) Which species of mosquito is the most domesticated, breeding around human habitations and only flying about 100 yards?

a. Aedes vexans. c. Culex tarsalis.
b. Aedes aetgypti. d. Culex pipiens.

15. (605) Which genus of mosquito makes up half of all North American mosquitoes, has more than 500 species and is distributed from polar regions to the tropics?

a. Aedes.
b. Culex.
c. Anopheles.
d. Mansonia.

16. (605) What mosquito is the most important salt marsh species and one of the most severe mosquito pests known?

a. Aedes aegypti.
b. Aedes dorsalis.
c. Aedes canadensis.
d. Aedes sollicitans.

17. (606) Which mosquito is the most important vector of malaria in the United States?

a. Aedes aegypti.
b. Aedes dorsalis.
c. Anopheles freeborni.
d. Anopheles quadrimaculatus.

18. (606) What is the most favorable temperature for the development of Anopheles quadrimaculatus?

a. 35 - 40° F.
b. 55 - 60° F.
c. 85 - 90° F.
d. 95 - 100° F.

19. (607) About how many species are there of the Culex mosquito?

a. 30.
b. 300.
c. 3,000.
d. 30,000.

20. (607) Which house mosquitoes are closely related and difficult to separate?

a. Northern and southern.
b. Eastern and western.
c. Northern and western.
d. Southern and eastern.

21. (607) Which genus has a habit of "singing" that is very annoying an is known as the house mosquito?

a. Aedes.
b. Culex.
c. Anopheles.
d. Mansonia.

22. (608) Which genus of mosquito remains below the water surface throughout the larval and pubal stages, obtaining air through the stem of aquatic plants?

a. Aedes.
b. Culex.
c. Anopheles.
d. Mansonia.

23. (608) Which mosquito larvae cannot be controlled by use of ordinary surface larvicides?

a. Aedes.
b. Culex.
c. Anopheles.
d. Mansonia.

24. (609) Which species of Aedes mosquito breeds in irrigated pastures of the west and is now the number one pest in the central valley of California?

a. Nigromaculis.
b. Infirmatus.
c. Tormentor.
d. Dorsalis.

25. (609) Which one of the following mosquitoes has spotted wings and is the most common culicine mosquito in the United States?

a. Inornata.
b. Incideus.
c. Confinnis.
d. Dorsalis.

26. (609) Which one of the following mosquitoes has been found to be naturally infected with the virus of western encephalitis?

a. Culiseta inornata.
b. Culiseta incidens.
c. Psorophora confinnis.
d. Psorophara ciliata.

27. (610) When determining the collection method to be used for collecting adult mosquitoes, which factor would be considered first?

a. The time of the year.
b. The species to be collected.
c. The number of mosquitoes present.
d. The number of personnel available.

28. (610) Which class of mosquitoes whould most likely be detected by using the landing rate collecting method?

a. Dangerous varieties.
b. Species which gather in small numbers.
c. Day-biting species.
d. Tropical species.

29. (610) Which of the following mosquito species can be effectively trapped by carbon dioxide traps?

a. Aedes vexans.
b. Anopheles freeborni.
c. Culex torsolis.
d. Culiseta melanura.

30. (611) Why are larval mosquito surveys conducted?

a. To determine the requirements for adult control measures.
b. To determine locations which personnel should avoid.
c. To determine specific breeding sites.
d. To locate adult mosquitoes.

31. (611) Why are special dippers used to collect mosquito larvae?

a. Because, they are less likely to disturb the larvae.
b. So their capacity can be directly related to the water surface area being examined.
c. So they will attract the larvae and entrap them.
d So they will not harm the larvae.

32. (611) If an area is found to be void of larvae during one collection, what should be done on future collections?

a. The area should be bypassed.
b. The area should be searched more thoroughly.
c. The area should be checked again.
d. The area should be sprayed before taking a new sample.

33. (612) When is chemical control most important?

a. When an area has a natural growth.
b. When the body of water is flowing.
c. When the larvae are too numerous for other methods.
d. Following floods or extended rainy periods.

34. (612) Which one of the following chemical formulations is least desirable for use as a larvicide in bodies of water?

a. Dusts.
b. Wettable powders.
c. Pellets.
d. Granules.

35. (613) Why are xylene solutions undesirable for residual sprays?

a. They are harmful to plants.
b. They are toxic to humans.
c. They are detrimental to screens.
d. They are too short lived.

36. (613) Which one of the following statements is true?

a. Extreme care must be exercised.
b. They are not too effective when safe amounts are used.
c. They are harmful to paint and furnishings.
d. They are safe, convenient, and effective.

37. (613) Which one of the following statements concerning space spraying is true?

a. It is effective for one month.
b. It is not effective.
c. It is effective temporally.
d. It is effective for one season.

38. (614) Which of the following best describes the disease carrying ability of flies?

a. They are mechanical carriers.
b. They are biological carriers.
c. They are chemical and biological carriers.
d. They are mechanical and biological carriers.

39. (614) Which one of the following factors of fly behavior is of the least importance?

a. Annoyance.
b. Bites.
c. Mechanical transmission of disease.
d. Biological transmission of disease.

40. (614) Which of the following are susceptible to myiasis?

a. Cattle.
b. Horses.
c. People.
d. All of the above.

41. (615) How many body regions does an adult fly have?

a. 2.
b. 3.
c. 4.
d. 5.

42. (615) How many stages are there in the life cycle of a fly?

a. 1.
b. 2.
c. 3.
d. 4.

43. (615) What is the common name for the larvae of most flies?

a. Maggots.
b. Eggs.
c. Pupae.
d. Melamorphosis.

44. (616) Which one of the following flies is considered the greatest threat to humans?

a. The horsefly.
b. The blackfly.
c. The housefly.
d. The deerfly.

45. (616) How do fly larvae regulate their temperature?

   a. By leaving the breeding place.
   b. By moving about in the breeding material.
   c. By excreting a fluid which evaporates.
   d. By a built-in temperature control system

46. (616) Which one of the following food ingredients is required in order for houseflies to produce eggs?

   a. Calcium.
   b. Fiber.
   c. Minerals.
   d. Protein.

47. (617) Which one of the following flies is the biological carrier of the two forms of African sleeping sickness?

   a. The tsetse fly.
   b. The stable fly.
   c. The false stable fly.
   d. The housefly.

48. (617) Which of the following fly species help to control other fly populations?

   a. The tsetse fly and the stable fly.
   b. The housefly and the dump fly.
   c. The dump fly and the false stable fly.
   d. The false stable fly and the housefly.

49. (618) Which one of the following features is an unusual characteristic of the flesh fly?

   a. They breed in animal flesh.
   b. The females deposit living larvae.
   c. They eat animal flesh.
   d. They deposit their eggs in animal flesh.

50. (619) What happens to blowfly larvae after they leave the breeding material?

   a. They burrow into the ground.
   b. They are ready to breed.
   c. They bore deeper into the material.
   d. They leave to start their own colony.

51. (619) Which one of the following fly species is active on warm winter days in the south?

   a. The blue blowfly.
   b. The black blowfly.
   c. The green blowfly.
   d. The bronze blowfly.

52. (619) Which one of the following fly species is a parasite of earthworms?

   a. The black blowfly.
   b. The screwworm fly.
   c. The green blowfly.
   d. The cluster fly.

53. (619) Why are screwworm flies more difficult to control west of the Mississippi?

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a. Because there is such a large expanse of land.
b. Because they are reintroduced from Mexico.
c. Because the climate is ideal for the screwworm.
d. Because there are so many more animals in the west.

54. (620) In what manner does the female bat fly deposit her eggs?

a. Directly to a warm blooded animal.
b. Directly to the ground.
c. Indirectly to a warm blooded animal through water.
d. Indirectly to a warm blooded animal by use of a vector.

55. (620) What kind of disease do the rabbit and rodent bat cause in humans?

a. Nasal and dermal myiasis.
b. Intestinal myiosis.
c. Tick fever.
d. Conjunctivitis.

56. (621) Why are eye gnats so difficult to control?

a. Effective insecticides are harmful to desirable plants and animals.
b. They breed in remote areas and are hard to reach.
c. They are parasites of desirable animals.
d. They breed in looose soil over vast areas of land.

57. (621) Where do filter flies create a very serious problem?

a. Around swimming pools.
b. In large eating facilities.
c. Around sewage treatment plants.
d. In water treatment facilities.

58. (621) How do soldier flies check the populations of domestic flies?

a. By eating housefly larvae.
b. By killing adult houseflies.
c. By keeping privy material soft and unfavorable for their larvae.
d. By keeping male houseflies from mating with females.

59. (622) In which one of the following locations would an insect net survey be used?

a. In an eating facility.
b. In an open dump.
c. In living quarters.
d. At an athletic field.

60. (622) How different species of flies be attracted to a bait trap?

a. By using a variety of baits.
b. By isolating the trap.
c. By lighting the trap.
d. By hanging the trap off the ground.

61. (622) Why is it difficult for flies to escape from traps?

a. They become frightened and disoriented.
b. The trap contains chloroform.
c. The flies are killed when they enter.
d. The openings are on the bottom and flies generally fly up to escape.

62. (623) Which one of the following would have the greatest effect in limiting a fly population?

a. The chemical controls used.
b. The physical and biological environment.
c. The long-range weather conditions.
d. Parasites and predators.

63. (624) Which one of the following control measures is considered mechanical?

a. Spraying.
b. Sterile male technique.
c. Parasites and predators.
d. Screening.

64. (624) Which one of the following mechanical control methods has no effect on the fly population?

a. Trapping.
b. Electrocution.
c. Screening.
d. Swatting.

65. (625) Which of the following items, when used alone, is inadequate for the storage of refuse?

a. Plastic bags.
b. Metal garbage cans.
c. Plastic garbage cans.
d. Metal bulk containers.

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66. (625) Which one of the following procedures is not considered as a sanitation method of domestic fly control?

a. Refuse disposal.
b. Spraying and fogging.
c. Refuse collection.
d. Weed control.

67. (626) Why is it necessary to identify fly species before applying chemical control measures?

a. So you will know how much chemical to use.
b. Because some flies are desirable and you don't want to kill them.
c. To determine whether to use a residual spray or not.
d. Because some flies have become resistant to certain chemicals, so you must know what to use.

68. (626) What precautions should be observed when applying space sprays?

a. Do not use indoors.
b. Make sure the chemical is authorized.
c. Do not use outdoors.
d. Do not use more than once a day.

69. (626) Why has flypaper been discontinued as a means of killing flies?

a. It does not work effectively.
b. It attracts more flies than would ordinarily be present.
c. It is unsafe to use.
d. Flies have become immune to it.

70. (627) What is the number one requirement of a good fly control program?

a. Cooperation.
b. Coordination.
c. Direction.
d. Education.

71. (628) What is the main objection to fleas?

a. They are pest annoyances to domestic animals.
b. They contribute to the breeding of other pests.
c. They are vectors of serious diseases.
d. They are annoying to humans.

72. (628) What is required by a female flea before she can produce eggs?

a. A blood meal.
b. A temperature over 72° F.
c. Plenty of organic food.
d. The absence of sunlight.

73. (630) Which one of the following fleas is the chief vector of bubonic plague?

a. The human flea.
b. The Oriental rat flea.
c. the northern rat flea.
d. dog and cat flea.

74. (631) What is done with rats immediately after they are captured during an ectoparasite survey?

a. They are killed.
b. They are placed in wire cages.
c. They are anesthetized.
d. They are placed in cloth bags.

75. (632) What usually accompanies the treatment of pets for fleas?

a. A short period of illness from the effects of the pesticide.
b. Discomfort from increased flea activity.
c. Skin irritations from the pesticide.
d. Human infestation from the fleas leaving the pet.

76. (632) Which one of the following pesticide formulations is most effective for outdoor treatment of fleas?

a. Emulsions.
b. Solutions.
c. Dusts.
d. Sprays.

77. (633) Which of the following would you most likely use to control fleas aboard an aircraft?

a. Dichlorvos.
b. Warfarin.
c. Red quill.
d. Zinc phosphide.

78. (633) To achieve a complete kill of oriental fleas aboard an unoccupied aircraft, you would use

a. Aerosol.
b. Micronized dust.
c. Emulsions.
d. Fumigants.

79. (634) How many stages of life do insects with incomplete or gradual metamorphosis have?

a. 2.
b. 3.
c. 4.
d. 5.

80. (635) The number of eggs the head and body lice may lay in one day is

a. 4 body lice and 9 to 10 head lice.
b. 9 to 10 body lice and 9 to 10 head lice.
c. 4 body lice and 4 head lice.
d. 9 to 10 body lice and 4 head lice.

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81. (635) The total life cycle of head and body lice is usually completed in about

a. 6 days.
b. 12 days.
c. 18 days.
d. 24 days.

82. (636) Which of the following statements is characteristic of the crab lice?

a. They lay their eggs along thick clothing seams.
b. They are often found on dogs and cats.
c. They survive briefly away from host.
d. They hibernate during the winter months.

83. (636) Crab and body lice are chiefly spread by

a. humans.
b. rodents.
c. birds.
d. dogs and cats.

84. (637) Which one of the following kinds of cloth is preferred by body lice for laying their eggs?

a. Rayon.
b. Linen.
c. Cotton.
d. Wool.

85. (637) When delousing clothing, you should pay very close attention to the

a. lapels.
b. collars.
c. seams.
d. pockets.

86. (637) What is the easiest stage of head lice to discover?

a. The eggs.
b. The larvae.
c. The pupal.
d. The adult.

87. (638) How long must a tick stay attached in order to transmit spotted fever?

a. One hour.
b. Two hours.
c. Three hours.
d. Four hours.

88. (638) What treatment is required for tick paralysis?

a. Removal of the tick and administering suitable antibiotics.
b. Immediate medical attention by a doctor.
c. Removal of the tick and application of a suitable antiseptic.
d. Remove tick and apply suction to remove venom.

89. (639) Which one of the following locations is least likely to contain large numbers of hard ticks?

a. In the ground around small vegetation.
b. Shrubbery areas.
c. Areas along paths.
d. Deep woodlands.

90. (639) What is meant by infection through interrupted feeding?

 a. Biological transmission from infected tick to healthy animals.
 b. Mechanical transmission of disease by a tick feeding on an infected animal and then feeding on a healthy animal.
 c. Biological transmission of disease by a tick feeding on an infected animal and then a healthy animal.
 d. Mechanical transmission from an infected tick to a healthy animal.

91. (640) How many legs does the seed tick have?

 a. 2.
 b. 4.
 c. 6.
 d. 8.

92. (640) The female soft tick can be identified by:

 a. A circular genital opening.
 b. An oval genital opening.
 c. Its large scutum.
 d. Its nymphal instars.

93. (641) One method of determining the infestation of ticks is by

 a. checking with the hospital.
 b. spraying and collecting the dead ticks.
 c. using a tick attracting trap.
 d. picking the ticks from the host animal.

94. (641) A tick drag should be used on an area of about

 a. 25 feet.
 b. 50 feet.
 c. 75 feet.
 d. 100 feet.

95. (642) Which of the following courses of action would you most likely take to help control tick infestation in residential areas?

 a. Spray the grass weekly.
 b. Cut the grass closely.
 c. Burn the grass yearly.
 d. Remove all hosts.

96. (642) How much tick repellent is needed to wet a complete uniform?

 a. 1 pint.
 b. 2 pints.
 c. 3 pints.
 d. 4 pints.

97. (642) Which of the following is a type of poison bait used to control field rodents infested with ticks?

 a. Warfarin.
 b. Polyethylene.
 c. Hexachlorophene.
 d. Nitro-Benzene.

98. (643) Which mite transmits rickettsialpox to humans?

a. Bird and chicken mites.
b. House mouse mites.
c. Grain and cheese mites.
d. Straw-itch mites.

99. (643) Which of the following mites is the intermediate host of certain tape worms?

a. Bird and chicken mites.
b. House dust mites.
c. Beetle mites.
d. Grain and cheese mites.

100. (643) Which mite does not bite man, transmit disease or damage foodstuffs?

a. House mouse mites.
b. Bird and chicken mites.
c. Itchmites.
d. Clover mites.

101. (645) Which mites are tiny, pale gray or yellowish-white and have conspicious long hairs?

a. Grain and flour mites.
b. House mouse mites.
c. Itch mites.
d. Northern fowl mites.

102. (645) Which of the following mites is normally a parasite of insects that bore into grain or wood?

a. Grain and flour mites.
b. Straw-itch mites.
c. Tropical fowl mites.
d. Northern fowl mites.

103. (645) Which of the following mites can be identified by its large dorsal and anal plates, short sternal plate, and needle-like chelicerae?

a. Grain and flow mites.
b. Straw-itch mites.
c. Chicken mites.
d. Tropical rat mites.

104. (646) Black glass plates or cardboard rectangles are used in surveying areas infected with which of the following?

a. House mouse mites.
b. Bird mites.
c. Chiggers.
d. Flour and grain mites.

105. (647) Which of the following would be least likely used to reduce the chigger population in your yard?

a. Spraying with ethyl hexanediol.
b. Eliminating tall weeds.
c. Trapping rodents.
d. Keeping lawns closely cut.

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CDC 56650

ENTOMOLOGY SPECIALIST

(AFSC 56650)

Volume 5

Household Pests, Venomous Arthropods, and Reptiles

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THIS PUBLICATION HAS BEEN REVIEWED AND APPROVED BY COMPETENT PERSONNEL OF THE PREPARING COMMAND IN ACCORDANCE WITH CURRENT DIRECTIVES ON DOCTRINE, POLICY, ESSENTIALITY, PROPRIETY, AND QUALITY.

Preface

IN THIS VOLUME OF CDC 56650, *Entomology Specialist*, you will learn about venomous arthropods and reptiles as well as some significant household pests.

Appendixes A and B are included as a separate inclosure to Volumes 4, 5, 6, and 7.

Please note that in this volume we are using the singular pronouns *he, his* and *him* in the generic sense, not the masculine sense. The word to which these pronouns refer is person.

If you have questions on the accuracy or currency of the subject matter of this text, or recommendations for its improvement, send them to 3700 TCHTW/TTGOX, Sheppard AFB TX 76311. NOTE: Do not use the suggestion program to submit corrections for typographical or other errors.

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This volume is valued at 15 hours (5 points).

Material in this volume is technically accurate, adequate, and current as of August 1977.

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CHAPTER 1

NOTE: In this volume, the subject matter is developed by a series of Learning Objectives. Each of these carries a 3-digit number and is in boldface type. Each sets a learning goal for you. The text that follows the objective gives you the information you need to reach that goal. The exercises following the information give you a check on your achievement. When you complete them, see if your answers match those in the back of this volume. If your response to an exercise is incorrect, review the objective and its text.

Venomous Arthropods and Snakes

IN RECENT YEARS the number of hospital admissions due to bites and stings by venomous arthropods has exceeded admissions for treatment of snakebite. The arthropods most frequently listed as responsible have been wasps, bees, ants, caterpillars, spiders, scorpions, and centipedes. Only about a third of the deaths due to venomous animals in the United States in the last few years were caused by snakebite; the others were caused by venomous arthropods.

There are about 136 species of snakes in this country, only 21 of which are poisonous and likely to cause death. At least one deadly species of snake is found in every state except Alaska and Hawaii.

This chapter will cover the importance, characteristics, and controls of venomous insects, arachnids, and snakes.

1-1. Arthropod and Reptile Venoms

Injury from venoms produced by arthropods and reptiles is a common public health hazard. Millions of people within the United States are affected each year by the venoms that are produced by these creatures. This section covers the types of venom produced by arthropods and snakes, the mode of action of these venoms, and how these venoms are introduced into humans.

800. Provide the names of toxins that produce given effects.

Types of Venom Produced by Arthropods and Reptiles. There are five basic types of venom that arthropods and reptiles produce:

a. Hemolytic toxin.
b. Neurotoxin.
c. Urticating toxin.
d. Vesicating toxin.
e. Hemorrhagic toxin.

Most arthropods and reptiles in the United States produce a hemolytic venom.

Mode of Action of Venoms. Hemolytic toxin causes a breakdown of red blood cells. It may kill large blocks of tissue in the area of the envenomization.

Neurotoxin is a systemic toxin that affects the nervous system. It inhibits reflexes and may cause shock in severe cases.

Urticating toxin simply produces wheals (raised areas) on the skin.

Vesicating toxin produces blisters on the skin.

Hemmorhagic toxin prevents the normal clotting ability of blood. Thus, it causes a reddening of the skin in the area of envenomization.

Exercises (800):

Provide the name of the toxin that produces each of the following effects.

1. ____________________ Inhibits reflexes and may cause shock.
2. ____________________ Produces skin blisters.
3. ____________________ Causes a breakdown of red blood cells.

801. Relate given envenomization methods and venom types to the appropriate arthropods and reptiles.

Methods of Envenomization. Most envenomization occurs through stings and bites. Other methods include pinching and contact. The methods of envenomization, the types of venoms introduced, and the producers are outlined below:

Envenomization Method	*Toxin*	*Producer*
Stings	Hemolytic	Insects: wasps, mud daubers, yellow jackets, hornets, honeybees, and bumble bees. Arachnids: scorpions.
	Neurotoxin	Arachnids: scorpions (two species within the US).

Envenomization Method	*Toxin*	*Producer*
Bites	Neurotoxin	Arachnids: black widows and brown widows. Reptiles: coral snakes. Insects: wheal bugs (both hemolytic and neurotoxin).
	Hemorrhagic	Insects; bedbugs and thrips.
Contact	Urticating	Insects: puss caterpillars, IO moths, and saddle-back caterpillars.
	Vesicating	Insects: blister beetles Diplopids: millipedes
Pinching	Hemolytic	Chilopids: centipedes.

Exercises (801):

1. Match the producers in column A with the envenomization methods and toxin types in column B. The items in column B may be used more than once.

Column A	*Column B*
___ 1. Yellow jacket.	a. Neurotoxic bite.
___ 2. Scorpion.	b. Hemolytic sting.
___ 3. Black widow.	c. Vesicating contact.
___ 4. Bedbug.	d. Hemorrhagic bite.
___ 5. Puss caterpillar.	e. Neurotoxic sting.
___ 6. Millipede.	f. Hemolytic pinch.
___ 7. Centipede.	g. Urticating contact.
___ 8. Coral snake.	

1-2. Bees

This section covers the good and bad aspects of bees in relation to humans, the general characteristics of bees, important bee families, and measures that you can take to manage bees.

802. Identify given statements concerning the beneficial and detrimental aspects of bees as true or false, and correct the false statements.

Bees are generally more beneficial than detrimental to humans; however, the degree to which they help or hurt depends on the bee species and location.

Beneficial Aspects. Honeybees are the most beneficial bees to humans in respect to food production. These bees produce honey, and, most important of all, they pollenate crop-bearing plants. Honeybees also produce beeswax. Beeswax is used extensively as a sealant because it does not harden readily and remains pliable for many years. Beeswax is also used for lubricating bow strings.

Bumblebees are very beneficial to humans because they pollenate plants that cannot be pollenated by honeybees. Some plants have a nectary that is so deep that only the bumblebee with its long tongue can cross-pollenate them.

Although the carpenter bees are important in plant pollenation, this beneficial aspect is often overshadowed with its detrimental habits.

Detrimental Aspects. Honeybees, bumblebees, and carpenter bees are all important from the medical standpoint. The hemotoxic venom causes local pain generally followed by swelling and reddening of the sting area. Some people are naturally immune to bee stings and won't swell at all, while others will swell excessively and be confined to bed. In some cases, the effects of bee stings can cause nausea, fainting, and even death.

Carpenter bees are more important from an economical standpoint than from a medical standpoint because they cause considerable structural damage to wood buildings.

All bees can be a severe nuisance pest to humans at times.

Exercises (802):

In the space provided by each statement below, place a C to indicate a correct statement or an I to indicate an incorrect statement; correct the false statements.

___ 1. Bees are generally more beneficial than detrimental to man.
___ 2. Honeybees are more beneficial to man than bumblebees.
___ 3. Food production is one of the least beneficial aspects of the honeybee.
___ 4. Beeswax hardens and remains useful for years.
___ 5. Bumblebees pollenate plants that cannot be pollenated by honeybees.
___ 6. Carpenter bees are less beneficial than honeybees or bumblebees, but they are also less detrimental.
___ 7. Bee stings are often painful and cause sickness and discomfort but never death.
___ 8. Bees can be severe nuisance pests to humans at times.

803. Provide the names of the bees that best fit given descriptions.

Characteristics of Bees. All bees are insects belonging to the order Hymenoptera but not all belong to the same family nor do they have the same characteristics. Since the carpenter bees will be discussed in another volume, only the characteristics of the honeybees and bumblebees will be discussed here.

Honeybees. Honeybees belong to the family Apidae. They are characterized by their construction of vertical combs of wax and the fact that the queen alone cannot start a new colony. There are several races of honeybees, and each race has varying characteristics. For example, the Italian bees are a gentle race, but the German bees are agressive and need no prompting to sting. Fortunately, the Italian honeybees are more prevalent in the United States.

Honeybees are social insects that live in large colonies that may consist of 20,000 bees or more. Honeybees have a distinct social order that is known as a caste system. The castes of the honeybee consist of the queen, worker, and drone. The workers are actually sterile females and are the ones that are most often seen scurrying about. These workers are approximately 15 mm long and have very hairy faces and a saclike organ the pollen basket, on the outer surface of each hind tibia. The pollen basket is used for transporting pollen back to the hive.

Bumblebees. These bees belong to the family bombidae and generally nest inside holes in the ground, such as those constructed by burrowing animals. Bumblebees live in colonies during the summer but only the queens survive the winter. Bumblebee colonies differ from the honeybees in that there are several queens in a bumblebee colony as opposed to only one in a honeybee colony. The colonies also differ in that bumblebees have no worker caste. Thus, the undeveloped female queens must carry out all chores.

Bumblebees are much larger than honeybees and their bodies are hairier. They do not have pollen baskets but have a spur on each hind tibia.

Exercises (803):

Provide the name or names of the bees that best fit the following descriptions.

1. ________________ These bees belong to the order Hymenoptera.
2. ________________ These bees belong to the family Apidae.
3. ________________ There are several queens in this kind of colony.
4. ________________ These bees generally nest inside holes in the ground.
5. ________________ These colonies have no worker caste.
6. ________________ This kind of bee includes gentle Italian bees and agressive German bees.
7. ________________ Undeveloped female queens must carry out all chores.
8. ________________ These bees do not have a pollen basket.

804. Provided with situations that require the control of bees, state the techniques that would be most appropriate.

Control of Bees. Since most bees are very beneficial, you should make every possible effort to control them without harming them. You must also protect yourself to keep them from hurting you.

Personal protection. The best way to protect yourself from bees is to avoid them. If you see bees working in an area, leave them alone because most will not harm you unless you disturb them. If you are involved in outdoor activities, check the area thoroughly for signs of bee swarms or hives and avoid the areas that are occupied by bees if possible. People that are allergic to stings should undergo a series of desensitization shots to increase their tolerance to stings.

Physical removal. Honeybees can be effectively controlled simply by transferring established colonies from one area to another. To remove an established colony, expose the colony in order to cut away the combs. Fasten the comb portions containing brood into frames with cotton string to entice the bees into the hive. Keep the hive for a couple of days near the entrance to the area in which it was established. Remove swarms of honeybees from bushes or other exposed areas by holding a white cotton cloth beneath the mass and raking them gently away. After you have collected the bees, transfer them to beekeepers or to open fields.

When you give bees to beekeepers or collectors, you solve the problem of controlling them. In addition, you do the environment a favor and you don't have to kill the insects with chemicals.

Collecting honeybees is an art that should be done only by experienced people. If you are inexperienced, and you must remove honeybees, be sure that you are clothed properly and are wearing a bee net over your head. Wear loose fitting clothing with the cuffs of sleeves and legs tightened over gloves and boots to prevent the bees from entering. Tie the bottom of the bee net securely over the collar of your clothing to prevent bees from getting inside the net.

Chemical control. Bees are generally susceptible to insecticides (dusts, sprays, or aerosols) and are easily controlled when they are swarming or when the colony is exposed. Since bees are inactive at night and are massed in their colony, take control measures in the late afternoon or early evening.

Control of bees that have become established in inaccessible areas is more difficult and may require several treatments in order to kill the entire colony. Insecticidal dusts are more effective in this instance because they can be blown into the area for workers to carry into comb cavities. This process should be repeated weekly for 2 to 3 weeks.

Exercises (804):

For each of the situations below, state the control techniques that would be most appropriate.

1. A colony of bees has swarmed and is infesting a decorative bush outside the main entrance to the commissary; they are a serious threat to the commissary patrons.

2. A colony of unwanted bees is nesting in an animal burrow on the golf course; they are a hazard to golfers, and several people have been stung.

1-3. Wasps

At times, wasps become severe pests to humans, especially when they build nests near, in, or on homes.

This section covers the important activities and the general characteriestics of wasps as well as the measures that you can use to control them.

805. Complete given statements concerning the important activities of wasps.

Important Aspects of Wasps. Like bees, all wasps are medically important to humans because of their stinging ability, and, as with bees, the reactions of humans to their stings depend on each person.

Wasps are very beneficial to humans in food production, but most help in a different way than bees. Wasps do not produce honey, nor do they produce beeswax, but they serve as pollenators of plants to a small degree. Wasps are more important in food production as being parasites of many insects that are responsible for destroying crops.

There are several wasps that destroy vegetation, and there are others that parasitize insects and arachnids that are very beneficial to humans.

Exercisers (805):

Complete the following statements.

1. Like bees, all wasps are medically important to humans because of their ____________ ability.
2. The reaction of a person to a wasp sting depends on the ____________________ .
3. The most important aspect of the wasp benefit to humans is that they are parasitizers of many __________________ that are responsible for destroying ____________________ .
4. There are several wasps that destroy ________ ____________ .

806. Identify given statements pertaining to the general characteristics of wasps as being true or false, and correct those that are false.

General Characteristics of Wasps. Wasps belong to the order Hymenoptera, which is also represented by bees and ants. The adults have two pairs of membranous wings. The adult females have ovipositors that are used to make holes for depositing eggs or to sting humans and other animals. In some wasps the ovipositor is very prominent and nonretractible; in others, the ovipositor can be retracted into the abdomen, completely concealing it.

Most wasps that are more beneficial than detrimental to humans are loners and do not construct massive nests. This way of life might account for the fact that they are not considered to be severe pests of humans.

The significantly harmful wasps are generally social insects that build large nests around, on, or in human dwellings and work areas. These wasps are attracted to sweets, fruits, and meats. They may actually bite off portions of foods. This attraction explains their presence around human dwellings and picnic activities. The social wasps may construct mud nests that resemble beautifully fashioned vases, globes, or mud clods. They may also construct paperlike nests with exposed or concealed cells. These nests may be found around the eaves of buildings, within attics, in shrubs, brush piles, woodpiles, in holes in the ground, or under objects on the ground.

4
1
2
5

Exercises (806):

Place a C or an I in the spaces provided to identify the following statements as correct or incorrect; correct the false statements.

___ 1. Wasps belong to the order Hymenoptera, which is also represented by bees and ants.

___ 2. The purpose of the ovipositor in the female wasp is laying eggs.

___ 3. Wasps live in colonies and are severe pests to humans.

___ 4. Wasps that do live in colonies construct nests of mud or a paperlike substance.

___ 5. Wasp nests may be found in a variety of different locations.

807. Complete given statements concerning measures that you can use to control wasps.

Wasp Control. Avoid killing wasps simply for the sake of killing them. If an occasional wasp appears indoors, the occupant can control it by letting the wasp out or by using a common insecticide aerosol bomb.

To control wasps that have established nests indoors or outdoors, you should treat the nests with approved insecticidal dust or solution formulations. Treat the nests, at night when all the wasps have returned to the nests and are inactive. Even though the wasps are inactive at night, you must wear protective clothing and a head net.

Always adhere to the use, application, and special precaution instructions on the pesticide label and/or those that are provided in Appendix G of AFM 91-16, *Military Entomology Operational Handbook.*

To keep wasps from entering indoor areas, make sure that facilities are screened properly and that doors and windows fit snuggly in their frames.

After you have treated the nests, and wasp activities have ceased, remove the nests and crush them to destroy the egg, larvae, and pupae stages. Remove and destroy all nests that you find in the winter season to prevent their reuse.

Exercises (807):

Complete the following statements concerning control measures for wasps. You may need to refer to Appendix A (in a separate inclosure).

1. Killing wasps just for the sake of killing them should be ________________ .
2. An occasional wasp indoors can be controlled by ________________ ________________ ________________ or by using an ________________ ________________ .
3. Wasp nests should be treated with ________________ or ________________ ________________ at ________________ .
4. Even though wasps are inactive at night you should ________________ ________________ ________________ when treating nests.
5. After nests have been treated and all activities have ceased, nests should be ________________ and ________________ to destroy the ________________ , ________________ , and ________________ stages.
6. Nests found in the winter should be ________________ to prevent their ________________ .
7. The proper pesticides to use for controlling various types of bees indoors or outdoors includes ________________ , ________________ , or ________________ .
8. The percent strength for propoxur used to kill bees should be ________________ .
9. The form for carboryl used to kill bees should be ________________ .
10. The method used to apply resmethrin to kill bees is to ________________ ________________ ________________ ________________ .

1-4. Hornets and First Aid for Stings

Although hornets in all actuality are wasps, they are included in a separate section because their characteristics are somewhat different from the other types of pest wasps.

This section covers the characteristics of hornets, controls for hornets, and the first-aid treatment for hymenoptera stings.

808. Correct given false statements pertaining to the importance, classification, and habits of hornet.

Importance. Although hornets parasitize certain insects and arachnids, their danger to humans overshadows their small degree of helpfulness. These insects are very vicious and inflict very painful stings, even more painful than the yellow jacket wasps. Of course, the effects of hornet stings depend on the individuals that have been stung, as in cases of other Hymenoptera stings. Hornets are the most feared of all the Hymenopterous insects.

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Classification. Hornets belong to the order Hymenoptera, family Vespidae, as do the more common pest wasps. The hornet that is most common and distributed throughout the United States is the baldfaced hornet *(Vespula Maculata).*

This species is a large (approximately 22 mm long), black and white hornet. The thorax and abdomen is much broader than other wasps and these parts are not separated as distinctly as the thorax and abdomen of other wasps.

Habits. Hornets construct paperlike nests like some other pest wasps, but the nests of hornets are completely inclosed with a paperlike covering and may resemble a massive oblong-shaped ball being wider near the suspended end. The nests of these insects are often attached to a tree limb or beneath any projecting surface.

Control. Hornets can be controlled effectively by using the measures previously outlined to control bees and wasps.

Exercises (808):

1. Correct any incorrect statements.
   a. Hornets are a very vicious variety of wasp.
   b. Hornets are important to humans from a medical standpoint.
   c. The sting of the hornet is worse than all other bees except the yellow jacket.
   d. Hornets have no beneficial qualities in respect to humans.
   e. Hornets construct large oblong nests of a paper-like material and are inclosed.
   f. Hornets are controlled by the same procedures as other bees.

809. Complete given statements pertaining to the first-aid treatment of Hymenoptera stings.

First Aid for Hymenoptera Stings. Unless you have received several stings at one time or are allergic to stings, a good first-air treatment is normally sufficient. However, if you have received many stings or if you are allergic to stings, you should receive treatment for shock and get medical help as quickly as possible.

Unlike the wasp and hornet, the ovipositor of the bee has barbs on it. Therefore, when the bee uses it as a weapon, the sting, poison sac, and other parts of its anatomy are torn from the bee's body and remain in the victim. Thus, the first-aid treatment for bee stings differs from the treatment of wasp, and hornet stings in that the bee sting must be removed.

To remove the sting, place the sharp edge of a knife blade immediately below the sting entrance and position it flat against the skin with the sharp edge closest to the exposed portion of the sting. Carefully pull the blade in the same direction as the angle of the sting to avoid breaking the sting off. This method prevents squeezing more venom from the poison sac. DO NOT use tweezers.

Once the sting has been removed, apply a paste of water and bicarbonate of soda to the inflamed area.

NOTE: Never rub a sting area. Rubbing only speeds the flow of venom into the blood and increases the area of inflammation.

Exercises (809):

Complete the following statements pertaining to the first-aid treatment of Hymenoptera stings.

1. If you are allergic or have received several stings you should obtain ______________ ______________ as soon as possible.
2. Treatment for a bee sting differs from a __________ or ______________ sting in that the ____________ must be ________________ .
3. Since the bee sting has a poison sac attached to it, you should *not* try to remove it with ____________.
4. Medication for a bee sting consists of a __________ of water and ______________ of ____________.
5. A bee sting should never be rubbed because this action only ______________ the flow of ______________ into the blood and increases the area of ______________ .

1-5. Spiders

There are only a few spiders that are dangerous to humans within the United States, but spiders of all types are probably more feared by humans than any other venomous arthropod. This fear of spiders is a result of not knowing their characteristics and not recognizing the few species that are dangerous.

The intent of this section covers, the general characteristics of spiders, the most medically important spiders within the United States, spider habits and habitats, as well as measures that can be implemented for managing spiders.

810. Identify as true or false given statements pertaining to the importance and potential danger of spiders, and correct the false statements.

Importance of Spiders. Contrary to the popular belief that most spiders are poisonous and harmful, they are actually more beneficial than detrimental. Spiders occupy a wide variety of ecological niches, ranging from treetop level in tropical rain forests (hunting or wolf spiders), to positions over well defined hunting trails, to silk-lined, underground tunnels.

All spiders are predaceous, feeding largely on insects. Because of their habits, they can often play an important role in maintaining the balance of nature and limiting insect populations. Dangerously venomous spiders occur in or around living quarters where people brush against webs or are bitten while putting on clothing in which spiders are hiding.

The most important species are members of the genera *Atrax* in Australia; *Harpactirella* in South Africa; *Chiracanthium* in portions of the Far East and the Pacific Islands; *Glytocranium, Phoneutria, Pamphobeteus, Ctenus,* and *Lycosa* in some portions of South America; and *Loxosceles* in South, Central, and North America. The most important species that occur within the United States belong to the genera *Latrodectus* (widow spiders) and *Loxoceles* (brown spiders).

The important spiders within the genus *Latrodectus* include the black widow *(Latrodectus mactans),* brown widow *(Latrodectus geometrices),* red widow *(Latrodectus bishopi),* and the Northern widow *(Latrodectus variolus).*

The brown recluse (*Loxoceles reclusa)* is the only poisonous member of the genus *Loxocelese* that occurs within the United States.

The most important poisonous spider within the United States is the black widow spider. The bite of the female black widow spider, although not as important as generally believed, can produce death, the death rate running approximately 5 percent. Although very young children or the very aged are supposed to be most susceptible to black widow spider venom, most US deaths occur among males bitten in the genital area, usually while using outdoor privies. The majority of deaths in this country are among migrant workers in the California vegetable fields. The male black widow spider has very little venom and the mouthparts are not strong enough to penetrate human skin.

Both sexes of the brown recluse are capable of inflicting poisonous bites to mammals. The typical reaction following a bite by the brown recluse is necrosis (killed tissue) at the site of the bite. The victim may not be aware of being bitten for 2 or 3 hours, or a painful reaction may occur immediately. A stinging sensation is usually followed by intense pain. A small blister usually rises and a large area around the bite becomes congested and swollen. The patient may become restless, feverish, and have difficulty in sleeping. The local pain is frequently quite intense and the area surrounding the bite remains congested and hard to the touch for some time. The tissue affected locally by the venom is killed and gradually sloughs away, exposing the underlying muscles. The edges of the wound thicken and are raised while the central area is filled by dense scar tissue. Healing takes place quite slowly and may take 6 to 8 weeks. The end result is a sunken scar which has been described as resembling a hole punched or scooped from the body. Scars ranging from the size of a penny to a half-dollar have been reported. The necrotic condition described above is typical of all bites of the brown recluse. However, in some cases a general systemic reaction has also occurred. The systemic disturbances probably occur infrequently and are the result of a "full" bite (i.e., the injection of a maximum amoun of venom), or extreme sensitivity to the venom. This general reaction to the bite of the brown recluse usually requires hospitalization. Those in poor general physical condition, young children, and older people are more apt to be affected seriously by the bite of the brown recluse.

Exercises (810):
Identify the statements below as correct or incorrect, and correct the false statements.

1. Spiders are considerably more beneficial than detrimental.

2. Contrary to popular belief, all spiders are poisonous.

3. All spiders are predaceous.

4. Spiders play an important role in limiting the insect population.

5. Dangerously venomous spiders occur in a very few areas of the world.

6. The most important poisonous spider in the United States is the brown recluse.

7. The male black widow spider has very little venom and the mouthparts are not sufficiently strong to penetrate the skin of humans.

8. The female brown recluse is the only one of the species which is poisonous.

9. The full bite of a brown recluse is no more serious than a partial bite.

10. The very old or the very young are likely to be affected most seriously by the bite of a brown recluse.

811. Complete given statements concerning spider classification and characteristics.

Classification and Characteristics of Spiders. Spiders belong to the order Araneida in the class Arachnida. They are found worldwide, but most live in the temperate and tropical zones.

Many spiders use their poison to paralyze their prey. Although the venom is sufficient for this purpose with insects and some small animals, humans are not generally bothered. Very few spiders have mouth parts that can penetrate the skin of humans, and most of those that do have venom that can produce only local symptoms or an occasional allergic reaction.

Spiders, like other arachnids, have eight legs, no wings and no antennae. Unlike scorpions, ticks, and mites, spiders (fig. 1-1) have an unsegmented abdomen attached to the cephalothorax by a short pedicel or stalk. The eyes are simple, usually eight grouped together or separated across the head. The head also has a pair of antennalike or leglike pedipalps and a pair of chelicera with fangs. There are many types of spiders with considerable variation in size, color, locomotion, web-spinning characteristics, methods of hunting and catching prey, shelter-seeking, and other distinctive characteristics. After hatching from eggs, immature spiders pass through several instars before reaching sexual maturity. Typically, females pass through more instars than do males. The life span varies with such factors as food supply, natural enemies, temperature, and humidity. The black widow and the brown recluse have life cycles characteristic of most spiders.

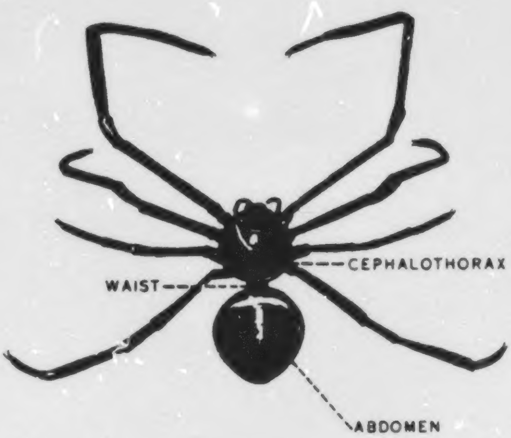

Figure 1-1. Black widow spider.

Exercises (811):
Complete the following statements concerning the classification and characteristics of spiders.

1. Spiders are generally found in ______________ and ______________ zones.

2. Many spiders use their poison to ____________ their prey.
3. The venom of most spiders is sufficient as far as insects and small animals are concerned; ____________ are not generally bothered by the venom of ______________ spiders.
4. Very few spiders have ______________ that can penetrate the ______________ of humans.
5. Typically, female spiders pass through more __________________ than males.

812. Match a list of spiders with statements pertaining to their identification, habits, and habitats; complete other statements pertaining to the black widow and brown recluse spider.

Black Widow Spider. The female black widow spider *(Lactrodectus mactans)* is 12 to 14 millimeters in length while the male is about half that size [illegible] entire body is usually a bright, shiny black (fig. 1-1) except for the markings; however, on some specimens the thorax and legs may be a dark brown. There are short, black hairs covering the body and legs but they are so fine that they are not usually noticed. The female has on the underside of the abdomen an hourglass-shaped spot which is usually a bright red, although orange to cream colors may occur on those found in some geographical areas. In addition, the males have rows of red spots and diagonal yellowish stripes of various straw colored markings on the upper surface of the abdomen. These markings may be present in various combinations. The legs may be alternately pale and black banded. Immature females vary in their markings so that their appearance may be between that of adult male and adult female.

The female black widow produces several sacs with an average of some 200 eggs each in round, creamy-white cases attached to her web. The eggs usually hatch in 2 to 4 weeks to very tiny, gray, active spiders which are cannibalistic. The eggs are usually laid during the summer and the young forms reach maturity the following spring. These spiders are found on the underside of privy seats, in piles of lumber and trash, and in empty paint cans and buckets. They are frequently found beneath houses in some areas, and they may occur in storerooms and garages. The web is extremely irregular and very loosely woven, and the tube into which the female retires is not in plain view. The black widows live in dark areas and generally avoid light. Their normal food is insects, and they usually bite man only if they are disturbed.

Brown Widow Spider. The female brown widow spider (Lactrodectus geometricas) is usually brown to grey in color and has the red to orange hourglass marking that is typical of widow spiders. At present, this spider is found only in Florida on or near buildings. Unlike the egg sacs of a black widow spider, the egg sacs of the brown widow spider are tufted and fluffy and honey gold in color.

Red Widow Spider. The female red widow spider *(Latrodectus bishopi)* is quite different in color from other widow spiders. The legs and cephalothorax are generally reddish brown and the abdomen is basically dark brown splotched with yellow and has a red to orange spot on the underside, unlike the hourglass marking that is typical of other widow spiders.

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The only place that this spider is found at present is in the palmettos and scrub-pines of southern and central Florida. The egg sacs of this spider are generally white, smooth, and round.

Northern Widow Spider. The female northern widow spider *(Lactrodectus variolus)* is very similar in color to the black widow spider except it is not shiny black but instead is smokey black.

This spider is distributed from northern Florida to southern Canada and is very common in British Columbia. It is generally found in isolated woods, in tree stumps, and in brick or stone walls.

The egg sacs of the northern widow spider are paperlike and brown in color.

Brown Recluse Spider. The brown recluse spider *(Loxosceles reclusa)* is of medium size, measuring about 10 to 15 millimeters long and 5 to 7 millimeters across. The legs are long. Both legs and body are covered with minute brown hairs but appear almost bare to the unaided eye. The body color varies from light fawn to dark brown. The most distinguishing mark is the dark fiddle-shaped band on the anterior portion of the carapace which narrows to a thin centerline extending almost to the abdomen (fig. 1-2). Unlike most spiders, this species and its close relatives have six instead of eight eyes.

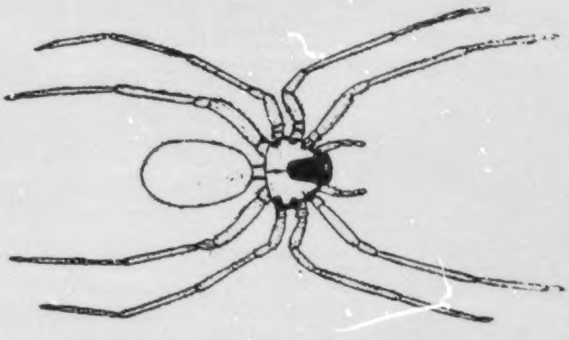

Figure 1-2. Brown recluse spider.

The brown recluse spins a medium-sized irregular web with a maze of threads extending in all directions without definite pattern or plan. The web fibers tend to be very viscid. In the laboratory this spider often constructs a retreat of loose silk in one part of its web. For a retreat in winter in its out-of-doors habitat, the brown recluse spins a tube of thick silk which somewhat resembles the hibernation retreat made by jumping spiders. Females usually produce more than one egg sack with a maximum production of five. Egg production averages about 135 with hatching occurring in 2 weeks. The setae of the young are very dark; the abdomen is yellow-brown; and the rest of the body color is pale tan. Except that the "fiddle" pattern is not evident on the carapace, the spiderlings resemble the adult. There are eight instars in the development to the adult stage, the first one occurring within the egg sac and all others outside. The duration of the second through the eighth instars is variable, sometimes extending for as long as 200 days. Indoors these spiders are commonly found in houses and associated buildings, boiler houses, schools, churches, libraries, stores, and other such buildings. Because the spiders are sedentary and avoid the light they are seldom seen, but they can be found in almost any place which has been relatively undisturbed for a long period of time, such as behind pictures, beneath and behind furniture, in boxes of toys, in clothing, and among stored papers. Even though the brown recluse has been found most often in and about houses, its natural habitat seems to be out of doors, at least in the southern part of its range. In outdoor locations it has been found beneath flat rocks, under loose bark, in crevices of old decaying logs, and in trash piles.

Exercises (812):

1. Match the spiders in column B below with appropriate statements concerning identification, habits, and habitats of important spiders in column A.

Column A

____ a. The male is about half the size of the female.
____ b. Red to orange hourglass marking.
____ c. Red to orange marking unlike the hourglass.
____ d. Covered with minute brown hairs.
____ e. Young spiders are cannibalistic.
____ f. Found in palmetto and scrub-pines of southern and central Florida.
____ g. Smokey black instead of shiny.
____ h. Fiddle-shaped marking on the anterior portion of the corapace.
____ i. Found in Florida.

Column B

1. Red Widow.
2. Brown recluse.
3. Black widow.
4. Northern widow.
5. Brown widow.

2. Complete the following statements which pertain to black widow and brown recluse spiders.
   a. The female black window produces several sacs with an average of ________ eggs each.
   b. The eggs usually hatch in ________ to ________ weeks.
   c. Black widows usually lay their eggs in the ________ and the young spiders reach maturity the following ________.
   d. Black windows are usually found on the underside of ________ ________, in piles of ________ and ________ and in empty ________ ________ and ________.
   e. The normal food of the black widow is ________, and they usually bite man only if ________.
   f. The most distinguishing mark of the brown recluse spider is the dark ________ shaped band on the back.
   g. The female recluse usually produces more than ________ egg sac with a maximum production of ________.
   h. Indoors, the brown recluse is commonly found in ________ and associated ________, ________ ________, ________, ________, ________, *and* ________, and other such buildings.
   i. Because these spiders are sedentary and avoid the ________ they are seldom ________.
   j. Although often found in houses the natural habitat of the brown recluse seems to be ________ ________ ________.

813. Complete given statements concerning the control of spiders.

Control of Spiders. Physical control methods, such as eliminating all possible breeding areas, are of considerable value in the elimination of black widow and other spiders. Care should be taken to destroy the webs in buildings and inhabited areas and to kill the spiders by crushing or with insecticides. The egg sacs found in the webs should always be destroyed, since as many as 300 young spiders may emerge from a single sac.

Approved insecticidal dusts and sprays (see Appendix A, in a separate inclosure) can be effective against spiders; and even aerosols can cause them to drop from their webs so that they can be crushed easily. Contact sprays and dusts containing carbamates and organophospates are effective. Standard stock items of dusting powders and of wettable powders, emulsions, and oilbase sprays will provide good control. Residual sprays will be less effective than contact sprays, but should be used in areas routinely frequented by poisonous spiders.

Exercises (813):

Complete the following statements which pertain to the control of spiders. You may need to use Appendix A (in a separate inclosure).

1. Physical control of spiders includes _____ _____ all possible _____ _____, _____ webs, _____ spiders, and destroying _____ _____ sacs.
2. Approved _____ dusts and sprays can be effective against spiders.
3. Aerosols can be used to cause them to _____ from their _____ so that they can be _____ easily.
4. Contact sprays and dusts containing _____ and _____ are effective.
5. Residual sprays are less effective than _____ sprays, but should be used in areas routinely frequented by _____ spiders.
6. The residual insecticides used for spiders are _____, _____, or _____.
7. The percentage of chlorpyrifos used for spiders is _____.
8. The form of the insecticide propoxur used for spiders is _____.

814. Complete given statements concerning first-aid treatment for spider bites.

Treatment for Spider Bites. Since the venoms produced by the widow spiders and brown spiders are different, they require different treatment. Treatment for the bites of widow and brown spiders must be administrered as soon as possible by trained medical personnel because first-aid treatment is ineffective and is, therefore, unnecessary.

Exercises (814):

Complete the following statements concerning firstaid treatment for spider bites.

1. First aid for widow spiders and brown spiders differs because of the different _____ produced.
2. The primary reason that first-aid treatment should not be rendered is that _____.
3. Treatment for medically important spiders must be administered as soon as possibly by trained _____ personnel.

1-6. Scorpions

Scorpions are most common in the southern regions of the United States from the Pacific to the Atlantic. Most scorpions within the United States are categorized as pests within buildings and outdoor areas frequented by humans. There are two scorpions of medical importance within the United States.

This section covers the importance, description, habits, and habitats of scorpions. You will also learn about the controls and first-aid treatment for scorpions.

815. Identify given statements pertaining to the importance of scorpions as being true or false, and correct those that are false.

Importance of Scorpions. There are 4 families with over 300 species distributed throughout the tropics, subtropics, and temperate regions of the world. Many scorpions invade dwellings in search of food or shelter. Others are normally found in the locations frequented by humans. While most scorpions can cause only painful stings, some species cause many deaths. The medical importance of a scorpion is determined by its habits and venom potency, not by its size. Some of the most dangerous species seldom attain a length of more than 7.5 centimeters. In contrast, stings by scorpions 12 to 15 centimeters long may produce only temporary local pain in man.

Most scorpions of medical importance are members of genus *Centruroides* in portions of the southwestern United States and throughout Mexico; genus *Tityus* in Central and South America; genera *Buthus* and *Androctonus* in the Middle East and North Africa, and genus *Parabuthus* in South Africa. Dangerous venomous species may also occur in other sparsely settled portions of Africa and Southeast Asia where no meaningful clinical records are kept. *Centruroides sculpturatus* and *Centruroides gertsdichi* are the only poisonous scorpions known to occur in the United States; both are found mainly in southern Arizona and parts of neighboring States.

Exercises (815):

Place the letter X in the provided space before each true statement, and correct any false statement.

___ 1. There are over 300 species of scorpions.
___ 2. The only poisonous scorpions in the United States are found mainly in southern Arizona and parts of neighboring states.
___ 3. Some of the most dangerous species of scorpions usually attain a length of more than 15 centimeters.
___ 4. Many scorpions invade dwellings in search of food or shelter.
___ 5. The medical importance of a scorpion is determined by its habits and venom potency, not by its size.

816. Complete given statements concerning the identification, habits, and habitats of important scorpions.

Identification, Habits, and Habitats of Important Scorpions. Scorpions belong to the order Scorpionida in the class Arachinida. Scorpions have four pairs of legs and one pair of, large claws or pedipalps. The body has two divisions—the anterior, unsegmented cephalothorax and the posterior, segmented abdomen. The last six abdominal segments form the "tail," with the end segment modified in the form of a hooked stinger (fig. 1-3). The end segment, or telson, has two poison glands. The tail is carried arched over the back, and the stinger is inserted into a victim by a quick forward thrust. The venom is ejected through the needle-sharp, hollow stinger. Adult scorpions vary in length from less than an inch. Colors vary from nearly black to straw-color; and some scorpions are striped. Most scorpions have smooth bodies, though some are hairy.

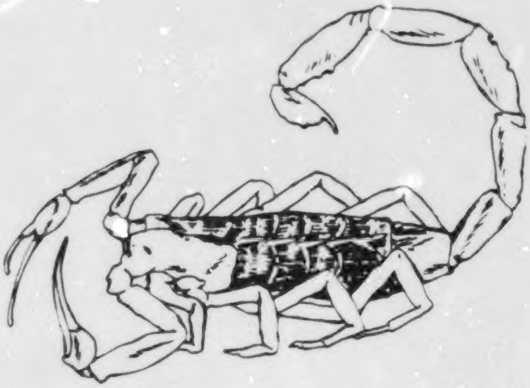

Figure 1-3. The scorpion.

The two poisonous scorpions in the United States are straw-yellow in color; *Centruroides gertschi* has two irregular black stripes on the upper surface of the body. The length is 5 to 8 centimeters and the width of the cephalothorax is approximately 6 millimeters. The tail is about 1.5 millimeters in diameter and bears a subaculear tooth at the base of the stinger. The pedipalps are long and slender.

Scorpions do not lay eggs, but bear their young alive. The young are carried for some time on the back of the female. Scorpions are nocturnal and are seldom seen during the day unless they are disturbed in their hiding places. The most common poisonous species in the United States, *Centruroides sculpturatus*, is frequently found under loose bark of various trees, particularly eucalyptus and cottonwood or under old logs and rocks. They are found occasionally on outside walls, particularly on buildings where a large amount of water is present, such as wash houses. They are also frequently found under wet rags, in folds of newspaper and magazines, and occasionally on clothing taken from a clothes basket. Indoors, scorpions are found in areas where insects are plentiful, such as under the house, in attics, or in hollow walls. In some buildings, scorpions may be found more or less routinely which indicates that they are breeding in the area. However, if they only appear once or twice a year they are probably being brought into the house in packages of vegetables, boxes, and firewood.

Exercises (816):

1. Scorpions have ________ pairs of legs and 4 ________ pair of large claws or pedipalps. 5
2. The body has ______ divisions; the anterior, ________ celphalothorax, and the posterior 2 ______ abdomen.
3. The last six abdominal segments form the ________ , with the end segment modified in the form of a hooked ________ .
4. The two poisonous scorpions that occur within the United States are ______ ______ in color; *Centruroides gertschi* has two irregular ________ stripes on the upper surface of the ________ .
5. Scorpions are ________ and are seldom seen during the ________ unless they are disturbed in their hiding places.
6. Scorpions are found occasionally on outside walls, particularly on buildings where a large amount of ________ is present.
7. Indoors, scorpions are found in areas where insects are plentiful, such as under the ________ , in ________ , or in hollow ________ .

817. Complete given statements concerning the measures that can be implemented to control scorpions.

Control of Scorpions. Avoidance is the best method of physical control and should include: picking up objects carefully so as not to be stung by the scorpions which may be hiding beneath them, emptying shoes and slippers vigorously before putting them on, not walking around barefooted after dark, and shaking out clothing. Clothing should not be dumped on the floor but should be hung carefully, and preferably away from the wall. Folded bedding may also serve as hiding places for scorpions. Beds in heavily infested areas should be kept away from the walls; and in some cases it may be necessary to place the legs of the bed in clean, widemouthed glass jars. These jars should not have water placed in them, as this might lead to mosquito breeding.

General cleanup of trash piles will help control scorpions by cutting down on their hiding places. It should be remembered that insects are the principal food for scorpions, and that killing such insects, particularly those that live on the ground, will be of benefit. Scorpions can go into hiding for 2 or 3 months after a period of abundant food, and can live as much as 6 months without food or water. Many species require from 3 to 5 years to reach maturity; thus, hunting out and destroying these animals on a regular basis will cut down on their numbers enormously.

Trapping of scorpions can be carried out in heavily infested areas by dampening a burlap sack or other piece of heavy coarse cloth and spreading it on the ground in the evening. Scorpions will crawl under it during the night and can then be easily destroyed the next moring. Cats, although of very little value in mouse control, can be quite effective in controlling scorpions, but they must be trained. Dogs are of little value against scorpions but are quite likely to be stung by them and possibly killed.

Many attempts have been made to control scorpions by the use of fogs, mists, and aerosols. Generally speaking, these methods are of very little value because of the scorpion's habit of hiding in cracks and crevices which are seldom reached by such treatment. Residual spraying or dusting of breeding areas provides good control. See Appendix A (in a separate inclosure) for pesticide recommendations.

Exercises (817):

1. The principal food for scorpions is ____________.
2. Scorpions can go into hiding for __________ or __________ months after a period of abundant food.
3. General cleanup of trash piles will keep control of scorpions by cutting down on their____________ places
4. Trapping of scorpions can be carried out in heavily infested areas by dampening a __________ sack and spreading it on the ground in the ________________.
5. The two pesticides used to control scorpions are ______________ and ______________.

818. Complete given statements pertaining to first-aid treatment for scorpion stings.

First-Aid Treatment for Scorpion Stings. Follow the procedures below for a victim stung by a poisonous scorpion:

(1) Immediately after the sting, place a ligature (a tourniquet) between the sting and the body. Tie it as near to the sting as possible to prevent rapid absorption of the venom. A shoelace or something equally slender makes a good ligature, but a handkerchief is poor. The ligature should be loosened briefly every 10 to 15 minutes.

(2) Put an ice pack directly on the site of this sting and have the victim hold it there.

(3) Antivenins are available for the poisonous US and Mexican species and some others; thus, professional medical assistance must be obtained as soon as possible.

Exercises (818):

1. Immediately after being stung, a ____________ should be placed between the ______________ and the ________________.
2. A piece of ______________ should be placed directly on the site of the sting.
3. The ligature must be loosened every __________ to __________ minutes.
4. For the poisonous US and Mexican species of scorpion there are available ______________.
5. Even if first aid has been rendered ___________ medical assistance must be obtained as soon as possible.

1-7. Other Venomous Arthropods

This section identifies venomous arthropods of less medical importance than those already covered in this chapter. They are less significant because they do not attack often and are not very toxic to humans. The arthropods covered here are centipedes, millipedes, conenoses, catepillars, and moths. You will also learn about control measures for them.

Centipedes belong to the class Chilopoda. Millipedes belong to the class Diplopeda. Both are found mostly in the tropical, subtropical, and warm-temperature regions of the world. They are all predaceous, and have well-developed poison glands for killing their prey.

Conenoses, also known as assassin bugs, belong to the class Insecta, order Hemiptera, and the family Reduviidae. They are carnivorous insects and are generally predaceous to other insects and to arachnids.

Catepillars are the larvae of moths and butterflies, and are in the order Lepidoptera. In the United States, there are 10 families with species troublesome to humans. There are many more irritating species scattered widely throughout the world. Our discussion will begin with centipedes.

819. Match a list of venomous arthropods with statements pertaining to identifying characteristics and effects.

Centipedes. Centipedes are flattened dorsoventrally. The body is made up of a distinct head and 15 to 170 or more similar segments. Each segment has one pair of tracheal openings and one pair of strong mandibles, and two pairs of maxillae. Individuals of some species attain a length of 25 centimeters or more. Adults of several species have shining greenish or blackish bodies, and orange or red legs and heads. Some are yellowish with dull red, longitudinal bands. Some centipedes are markedly phosphorescent. Sexes of centipedes are distinct, and the females either lay eggs or give birth to living young. The young resemble the adults, having approximately the same number of segments.

Centipedes differ from millipedes (class Diplopoda), which have two pairs of legs on each body segment, a nearly rounded rather than flattened body, and which feed principally on decaying vegetation. Centipedes hide by day under stones, rubbish, leaves, logs, and in other dark areas. They feed by night on earthworms, insects, mice, or lizards, depending on their size. They kill or paralyze their prey quickly with venom and chew it for ingestion with their mandibles. The common, long-legged house centipede *(Scutigera forceps)* is usually regarded as quite beneficial because it feeds on household insects.

Importance. Most centipedes are harmless, since only a small number have fangs strong enough to penetrate human skin. They bite large animals only in self defense. The secretion injected is primarily a digestive enzyme, containing only a small proportion of venom. The amount of this material introduced depends somewhat on the size of the centipede and on the time elapsed since the fangs were last used. The small, fast running, house centipede *(Scutigera cleoptrata)* has been known to pierce the skin and cause pain. The larger house centipede *(Scutigera forceps)* can bite and cause intense local pain. Other centipedes can also inflict very painful bites. The 2.5 centimeter *Scolopendra gigantea* of the Tropics is considered very poisonous, its bite sometimes requiring hospitalization of victims.

Effects and first aid. Centipede bites may cause local pain, erythema, hardening of the skin, formation of papules, rash, swelling, purple patches, and swollen axillary glands, but such symptoms usually subside within 24 hours if the wound is uninfected. There have been no deaths recorded from the bites. Treatment usually consists of locally applied palliatives, such as weak ammonia, compresses of sodium bicarbonate, or epsom salts.

Millipedes. Millipedes are more cylindrical than flat. The body is made up of a distinct head and a trunk that consists of several segments. Each trunk segment bears two pairs of jointed walking legs which lack poison claws. The head bears a pair of short antennae, a pair of mandibles, and two pairs of maxillae.

Millepedes range in size from less than 2.5 millimeters to 16 centimeters. They are slow moving despite numerous legs, and are nocturnal, secretive, vegetarian, and terrestrial. They lay eggs, and the young resemble the adults but have fewer abdominal segments and only three pairs of walking legs.

Importance. Millipedes may be accidental parasites of humans, inhabiting the intestinal and urinary tracts. Some produce offensive fluids from paired glands located in the abdomen. These fluids have sometimes produced a dermatitis in humans.

First aid. Victims that have been contaminated with the fluid excreted by millipedes should deluge the contaminated area with soap and water immediately. This will remove the fluid and should be all that is required.

Conenoses (Assassin Bugs). Conenoses have a cone-shaped head, with a three jointed proboscis that is carried in a folded position close to the body. When disturbed, the proboscis is projected forward in a manner similar to a spring that has been bent over and one end released. Conenoses range in size from 12 to 25 millimeters and are basically brown in color. Some have white to yellow wide spots on each side of the abdomen. The winds are about as long as the abdomen and are folded one on top of the other.

These insects are attracted to lights at night and will commonly enter buildings. They are blood-sucking insects that usually feed upon other insects although they will readily feed on mammals, including humans. Some species have been so persistent in human bedding that they have been referred to, and are commonly known as, Mexican bedbugs. Conenoses can produce a very severe reaction through their bites to humans even though the bite might not be felt at the time of injection.

Conenoses lay their eggs on plants in outdoor areas, but, inside, they lay the eggs in dark, dusty cracks, crevices, and corners. The eggs hatch into nymphs and the nymphs pass through eight nymphal instars before reaching the adult stage.

Importance. For the most part, conenoses are beneficial to humans in that they attack other insects and are known to be predaceous upon bed bugs. However, they are also known to be vectors of Chaga's disease, and they produce a very strong hemolytic-neurotoxin venom. The bite of these insects may not even be recognized (because of the anesthetizing effect) until the insects have completed their feeding, which might last anywhere from 3 to 7 minutes.

Effects and first aid. There may be no reaction to the bite of a conenose by some individuals, but, to others, the reaction might be severe with the effects of the venom lasting for several months. The venom produced by conenoses is hemolytic and neurotoxic. You should treat the bite area with iodine to prevent secondary infection. Place a paste of bicarbonate of soda and water over the bite area along with an ice pack to localize the venom and to give temporary relief until you can get professionsl medical assistance.

Caterpillars and Moths. The larvae of some moths and butterflies have large spines which, while harmless, create the false impression that the caterpillars are dangerous. On the other hand, most of the caterpillars with urticating or netting hairs appear harmless. Some are actually attractive, being strikingly colored. Lepidoptera exhibit complete metamorphosis. The caterpillars hatch from eggs, and, upon maturity, transform to pupae. Most species of moths spin cocoons in which they pupate. Most species of butterflies do not. After pupation, the sexually mature adult emerges. Most adults are capable of flight, but some females are wingless.

While the medical importance is due primarily to urticating hairs, some caterpillars, such as the larvae of the cabbage butterfly *(Pieris brassicae)*, have poisonous body fluids which produce intestinal inflammation and death in cattle which ingest the caterpillars with food. One caterpillar, the mealworm *(Asopia farinalis)*, can act as the intermediate host of the rat tapeworm *(Hymenolepis diminuta)* which occasionally infests man. Ophthalmia nodosa is a disease of the conjunctiva, cornea, or iris of the eye caused by nettling hairs. In a few cases, the adult Lepidoptera have nettling hairs; but in some of these cases, these are larval hairs adhering to the adult. Symptoms produced by the urticating hairs differ with the species of moths and with the individual reaction differences of the victims. Cases of caterpillar rash are more widespread than commonly supposed, and can be easily misdiagnosed in areas where not very common. The venom of caterpillars is produced in glands located at the bases of hairs, sometimes outside the body surface. These may occur singly or in clusters of tubercles on the body of the insect. Upon contact of the spines with the victim's skin, the venom may emerge through an opening at the tip of the spine; or a portion of the hair or spine may break off in the wound, thus releasing the venom. The more important venomous Lepidoptera are described below.

Puss caterpillar. The puss caterpillar is about an inch long when full grown. It has a thick, fleshy body completely covered and hidden by long silken hairs of a tawny to greyish color. The upper side appears to have a convex form. Under the long hairs are numerous short spines in rows on tuberculate ridges and connected with underlying hypodermal poison glands. This species is quite common in the Southern States, and at times becomes very abundant. At such times a great many cases of stinging have received medical attention. Schools have been closed in some areas until the caterpillar was brought under control. The severity of the symptoms depends largely upon individual reactions. The initial reaction is usually an intense, burning pain immediately after contact. This is followed by raised papules and reddening, then by generalized swelling and numbness, which may be accompanied by nausea and vomiting. Stings on the wrist have resulted in swelling of the entire arm to about double size. Fever and symptoms of nervous disorder are not uncommon in children.

Brown-tail moth. The brown-tail moth larva is about 3.8 centimeters long. The head is light brown, the body dark brown to almost black with a broken white line on either side and two conspicuous reddish spots on the back near the posterior end. Numerous tubercles with long, barbed hairs and with short, brown hairs between are located on the back and sides of the body. This insect is a serious pest of fruit and shade trees in the Northeastern States. The larvae are the most notorious of our poisonous caterpillars. Short, barbed hairs are easily lost by the catepillar. Further, the cocoons and even adult moths harbor these hairs; and they are easily carried by wind currents. On striking the skin, these hairs cause intense itching on exposed parts of the body. They adhere to clothing drying on the line; then they cause severe dermatitis when the clothing is worn. Ingestion of these hairs by swallowing or inhaling can cause serious internal disturbances and injury. Nodular conjunctivitis is caused by these hairs getting into the eye.

White-marked tussock moth. This moth has a larva which is considered one of our most beautiful caterpillars. The head and the glands of the sixth and seventh abdominal segments are a bright vermillion. A band on the back is velvety black, bordered with yellow, subdorsal stripes. There is another yellow band on each side just below the spiracles. On each side of the prothorax there is a slender tuft of long, black hairs with plumelike tips. A similar brush is located on the back of the eighth abdominal segment. The first four abdominal segments have dense, brushlike tufts of cream colored or white hairs. This moth is a general feeder on foliage of deciduous trees and shrubs, and is often a serious pest of shade and fruit trees. It is found from Colorado to the Eastern States. The short barbed hairs can cause considerable skin irritation. The nettling hairs are found on all stages of the larvae. They are scattered over the body in the first two instars, while they are localized in the white dorsal tussocks of the first four abdominal segments in the later states. The hairs are interwoven in the cocoons at the time of pupation.

IO Moth. This moth is widely distributed throughout the Eastern and Central States. The larva is probably the most generally known of the nettling caterpillars in the United States. It feeds on a wide variety of food plants, including willow and even corn. The full grown larva is abut 6.4 centimeters long. It is pale green with sublateral stripes of red and cream. Numerous green spines, with a few black ones among them, radiate from tubercles on the body creating a mossy appearance. Some of the long spines bear hairs; but the poison spines have peglike tips and are connected with very large venom glands. These spines do not normally break off and drift with the wind as do the spines of some catepillars. Only the tip breaks in the wound. Direct contact with the larva and its nettling spines is normally required to produce the intense itching caused by the venom.

Saddle-back caterpillar. This caterpillar is found throughout the Central, Eastern, and Southern States where it feeds on a wide variety of forest and fruit trees. However, it is not normally numerous in any location. It has a purplish-brown spot surrounded by a large green patch on the back giving the appearance of a dark saddle on a green saddle blanket. It has tufts of bristling stout spines with acutely pointed tips. The spines are connected with poison glands. The spine tips break off in the skin; and the venom is forced into the wound. The poison affects some people severly, causing extreme pain.

Exercises (819):

1. Match column A with column B.

Column A	*Column B*
____ 1. Generally feeds on foliage of deciduous trees.	a. Centipede.
____ 2. Purplish-brown spot surrounded by large green patch.	b. Millipede.
____ 3. Carnivorous insect and is generally predaceous to other insects.	c. Conenose (assassin bug).
____ 4. More cylindrical than flat.	d. Puss caterpillar.
____ 5. Flattened dorso-ventrally.	e. Brown-tail moth.
____ 6. Poison spines have peglike tips connected with very large venom gland.	f. White-marked tussock.
____ 7. Spines are connected to poison gland.	g. IO moth.
____ 8. Youths resemble adults.	h. Saddle-back caterpillar.
____ 9. Has cone-shaped head with three-jointed proboscis that is carried in a folded position close to the body.	

Column A

___ 10. Two pairs of legs on each body segment.
___ 11. Serious pest of fruit and shade trees in the Northeastern States.
___ 12. Under long hairs are numerous short spines connected to underlying hypodermal glands.
___ 13. Pale green with sublateral strips of red and green.
___ 14. The head is light brown; the body is brown to almost black.
___ 15. Head and glands of the sixth and seventh abdominal segment are bright vermillion.
___ 16. Thick fleshy body completely covered and hidden by long hairs of tawny to greyish color.

820. Complete given statements concerning the controls for centipedes, millipedes, conenoses, caterpillars, and moths.

Control of Other Venomous Arthropods. This objective outlines measures that may be used to control centipedes, millipedes, conenoses, and venomous caterpillars, and moths.

Control of centipedes and millipedes. Proper screening to keep centipedes and millipedes out of buildings and caution while disposing of these creatures are about the only preventive measures which can be recommended for avoiding their bites. Troops on duty in areas where large centipedes are prevalent should be advised not to touch them or attempt to catch them. Fortunately, large centipedes are seldom if ever so numerous as to necessitate special control measures. Properly fitting doors and good screening should keep centipedes and millipedes from living quarters. Troops in the field should use caution in putting on boots and other clothing which may have been on the ground overnight. Presence of centipedes and millipedes in tents in tropical areas is a good reason for sleeping in a properly "tucked-in" bed net. Contact sprays will kill centipedes and millipedes. Residual sprays are moderately effective. See Appendix A (in a separate inclosure).

Control of conenoses. Since conenoses fly readily and are attracted to lights, it is imperative that buildings are properly screened and door and windows fit snugly in their frames.

If a conenose happens to get on you and you are aware of it, brush it off gently and swiftly to prevent being bitten.

Where conenoses are abundant, you can apply residuals around doorways, window frames, and around lighting. Be sure to use insecticides that are recommended for this type of treatment and apply it according to the instructions provided.

Control of caterpillars and moths. Control measures for these venomous arthropods are the same as those that are used to control ornamental and turf pests which are discussed later in this course. You can find the recommended controls for caterpillars and moths in Appendix A (in a separate inclosure) under "Tent Caterpillars and Fall Webworms." When you use these control measures for those caterpillars that easily shed their netting spines, you should try to kill them in the shortest possible time. Slowly dying caterpillars move contortedly, and will shed many hairs and spines before they die.

Exercises (820):

1. Residual insecticides for control of centipedes is ______________ .
2. The residual insecticide used to control millipedes indoors is ________________ .
3. Where conenoses are abundant, ____________ can be applied around ____________ ____________ ________ __________ , and around ______________ .
4. To control tent caterpillar and fall webworms on ornamentals use ______________ , ____________ , and ____________ .

1-8. Snakes

In this section, you will learn about the identifying characteristics of poisonous snakes within the United States. This section will also provide you with information pertaining to snake habits, habitats, and bite symptoms, as well as the first-aid treatment for snakebites.

821. Indicate whether given statements pertaining to snakes are true or false, and correct those that are false.

Facts About Snakes. Snakes contribute an important part in maintaining the "balance of nature." They control destructive animals, such as field mice and other rodents. They have aesthetic value or beauty in themselves, just as birds do, and they are a very interesting group. Many have commercial value, the skins of which are used in making leather goods.

Snakes belonging to the families Crotalidae and Elapidae are poisonous; however, fatalities resulting from snakebite in the United States have never been high, considering the size of the country and its large population.

Fear of snakes is due to a lack of knowledge concerning the identification of poisonous snakes and some of the fallacies (not facts) that have been passed down through generations. The following are some of the common fallacies and facts about snakes:

a. Snakes are slimy. This is not true. Snakes are actually cleaner than we are. They have hard glossy shields and scales covering their bodies and for this reason appear slimy.

b. The forked tongue of some snakes is poisonous. No, the tongue is a harmless organ which is not poisonous (in even the poisonous species) and is a highly sensitive organ of taste and smell. It also detects vibrations.

c. The tails of some snakes sting or have poisonous properties. Some snakes such as the "horn snake" (the correct name of which is the mud snake) have hard, scaley, and pointed tails which they will deliberately press against your hand when you restrain them but their tails are *not* poisonous.

d. Some kinds of snakes commonly attack man. There have been two recorded instances of snakes having made unprovoked, offensive movements toward man. One was a black snake with her young and the other was an eastern diamondback rattlesnake with her young. Both snakes were in an inclosed area. Snakes are also prone to bite if they are disturbed when shedding skin and during the breeding period.

e. The glass snake is a snake. It is not a snake but a lizard with a tail twice as long as its body. The tail will grow back on if it is broken or knocked off.

f. Snakes can charm birds. No, the bird is frozen with fear or is pretending it is hurt to draw the snake away from its young.

g. A snake will not cross a horsehair rope. A horsehair rope does not stop a snake.

h. Snakes take milk from a cow. Snakes will drink milk from a saucer but not from the cow.

i. The hoop snake will chase a person by holding its tail in its mouth and rolling over and over. This fallacy is commonly attached to mud snakes also and is a physical impossibility. Snakes have a backbone just as man does.

j. The spreading adder or blow snake (correctly called the hog-nosed snake) exhales a poisonous vapor when approached or offended. These snakes do inflate their lungs and hiss loudly when disturbed but there is no poisonous vapor emitted. These snakes are so harmless that if the hissing sounds and flattened head do not succeed in scaring the attacker, the snake will roll over on its back, open its mouth wide, and play dead. It is also very hard to enrage or excite this snake enough to make it bite.

k. Snakes can't bite under water. Water moccasins eat fish, so how do they catch them? They bite them and inject poison.

Exercises (821):
Identify each statement as true or false. Correct the false statements.

___ 1. Snakes help in maintaining the "balance of nature."
___ 2. Poisonous snakes belong to the families Crotalidae and Elapidae.
___ 3. Fatalities from snakebite in the United States are relatively high.
___ 4. Snakes are not slimy.
___ 5. Snakes can't bite under water.
___ 6. The spreading adder exhales a poisonous vapor.
___ 7. People fear snakes because snakes often will deliberately make unprovoked offensive attacks on man.

822. Match a list of Crotalidae snakes with statements pertaining to their description, distribution, habitat, food, breeding, and habits, complete other statements concerning the Crotalidae snake family.

Family Crotalidae. The poison snakes of the United States belong to two families: Crotalidae and Elapidae. The Crotalidae, the family of long-fanged pit vipers, includes the bushmaster and fer-de-lance of South America and the copperhead, water moccasin, and rattlesnake of this country. Pit vipers strike their prey from a lateral loop and inject a large amount of toxic venom, which almost immediately overwhelms the victim. When the prey dies, or is almost dead, the snake swallows it.

Pit vipers are so named because of the facial pit between the eye and nostril on either side of the head. This pit is lined with a delicate epidermis and connects with a well-developed nerve which extends backward to the brain. Because of the presence of this nerve, it is believed that the pit is sensory in nature, being receptive to heat waves and thus directing the strike. The pupil of the eye is vertically elliptical, and the head is flat and triangular shaped, possessing a poison gland and retractable fangs rigidly attached at their base to movable maxillary bones.

Water moccasin. This is a stout and heavy-bodied snake with an abruptly tapering tail and a chunky, ugly head. The average size is 3 to 4 feet (91.44 cm to 1.22 meters in length but some specimens have been found which [illegible] 5 feet (1.52 m) in length. The body color is dark brown or olive with 10 to 15 wide, black, transverse blotches (barely showing, or not at all, on the back of old snakes), more sharply defined on the sides of the body than on the back. The upper and lower lip plates are yellow and the inside of the mouth is white; hence, they are commonly called *gappers* or *cottonmouths*. The abdomen is yellow and is blotched with dark brown or black. The young resemble copperheads because they have a pinkish or reddish brown coloration on the body with a coppery looking head. There is a broad dark band through the eye.

a. Distribution. Moccasins are found from the swamps of Virginia through Florida, along the Gulf States to East Texas. The range northward extends through eastern Oklahoma, Arkansas, Mississippi, southern Illinois, Indiana, and Tennessee.

b. Habitat. They are semiaquatic, found along sluggish streams, bayous, lagoons, and swamps and other bodies of water with thick, marginal vegetation.

c. Food. They feed on frogs, fish, other snakes, birds, small mammals, lizards, small turtles, baby alligators, and salamanders.

d. Breeding. It usually takes place in March, and 7 to 12 young are born alive in August or September. The pit vipers all produce living young (viviparous). The young are more brilliantly marked than the adults and, as we have mentioned, are frequently confused with copperheads.

e. Habits. Moccasins are sluggish and irritable in the wild state. A thoroughly aroused cottonmouth throws its head upward and backward and holds its mouth wide open, revealing the white interior. These very dangerous snakes resemble closely several of the nonpoisonous water snakes (Natrix) and are difficult to distinguish from them in the field. Behavior offers some of the best clues. Water snakes usually flee quickly or drop with a splash into the water, but cottonmouths often stand their ground with a vibrating tail or crawl slowly away. In the fall moccasins retreat to higher ground to hibernate and thus are not necessarily found in the immediate vicinity of water.

Copperhead. These are richly colored, heavy-bodied snakes with 15 to 25 chestnut-brown crossbands on the hazel or pinkish-brown body. These crossbands are constricted on the midline of the snake's body so that they appear as hourglasses from the top and as inverted Ys from the side. The average size of copperheads is about 3 feet (91. 44 cm) long. The uniform, coppery tinge of the head has given this snake its most popular name. The abdomen is pale pinkish brown, with a row of dark spots on each side (ventral view). The copperhead is also known in some parts of the country as a rattlesnake pilot, pilot, or chunk-head:

a. Distribution. They are found in central Massachusetts and through all of the Eastern States to northern Florida, along the Gulf States to Texas, thence northward through Arkansas, Oklahoma, Kansas, Missouri, Illinois, Indiana, Ohio, Pennsylvania, and New York.

b. Habitat. These snakes are arboreal as well as terrestrial, frequently climbing vegetation in search of food. They are found in rocky or wooded areas such as the mountainous and ledgy regions of the North and inhabit the damper deciduous woods and low-lying stretches of cypress growth of the South. These snakes are found together in small numbers throughout the year. They are commonly found in deserted quarries in the North, where they hibernate in the rocks with their close relatives, the banded rattlesnakes.

c. Food. This snake has a highly variable diet, feeding on small mammals and birds, other snakes, frogs, and insects such as caterpillars and cicadas. The food preference seems to be seasonal.

d. Breeding. Mating takes place in April or May and 6 to 12 brilliantly colored young are born alive in August or September. The young have sulphur-yellow tails.

e. Habits. As in the case with the other pit vipers, they coil and rapidly vibrate their tails when disturbed. Their coloration is highly protective, especially when these reptiles are motionless against a background of autumn-colored leaves. As a general rule, they are less irritable than the water moccasin and will seek cover swiftly when disturbed, except when they are cornered. Old stone walls and natural ledgy terrain should be approached with caution because they are common resting places for this snake.

Rattlesnakes. They are the most interesting and important reptiles inhabiting North America, because at least one species is found in every State except Alaska and Hawaii. Rattlesnakes are so named becaused they have horny interlocking joints at the end of the tail that make a sharp rattling sound when shaken. Some species attain such a large size that they rank high in point of deadliness among the venomous snakes of the world. They are highly variable, ranging from 18 inches (45.72 cm) in the case of the pygmy rattlesnake *(Sistrurus Miliarius)* to 6 feet (1.82 meters) in the case of the eastern diamondback rattlesnake *(Crotalus Miliarius).* The same species may vary in color. There is great color variation in both yellow and black phases of the banded or timber rattlesnake. The massasauga *(Sistrurus Catenatus)* is partial to bogs and swamps, while the horned rattlesnake, or sidewinder, thrives in dry desert areas. As we said before, rattlesnakes have been found in every State except Alaska and Hawaii, but their headquarters (according to number of species) is the southwest. Except for the southwest, there are few areas where more than one or two species occur. The borders of the ranges of the different species may extend slightly into that of another. Because of the highly diversified habits and characteristics of this group of snakes, we will consider only the eastern diamondback rattlesnake, the largest and most deadly poisonous reptile found in the United States. It ranks among the world's most deadly snakes:

a. Distribution. The eastern diamonback is found from Florida, in many of the adjacent keys, northward through the Coastal Plains to southern North Carolina and westward along the Gulf States to extreme southeastern Louisiana.

b. Description. It is a stout-bodied olive to dark brown snake with a hold pattern of large black or brown diamonds down its back. These diamonds have bright yellow borders, about the width of a single scale, and become obscure toward the tail. Beneath the eye is a dark band, bordered on each side with a narrow band of bright yellow. The abdomen is dull yellow. With the exception of a more vivid pattern, young specimens are like the parent. They commonly grow to 6 feet (1.82 m) but may attain a length close to 9 feet (2.74 m) and weigh 12 to 15 pounds (5.4 to 6.8 kg) or more.

c. Habitat. This snake inhabits the wild brush country of the southern lowlands, where pines and palmettos flourish. These snakes have been commonly observed hiding under the broad leaves of the dwarf palmettos during the day and leaving them at twilight to feed. So closely do the body colors blend with the vegetation and the effects of sunlight and shadow, that these snakes are seen with some difficulty.

d. Food. These huge snakes feed largely on rabbits and quail, principally the former. They wander into areas of dwarf and scrub palmettos in search of their prey. Hunters and other persons who have occasion to enter such diamondback-infested areas should take the necessary precautions to keep from being bitten. A description of the poisonous potentiality of this reptile is shown in the following example. The maneuvers of the average specimen when feeding in captivity are interesting—a medium sized rabbit is placed in the cage, and the snake shifts its coils to a striking posture. The rabbit shows no sign of fear and may hop toward the reptile, which draws back its head. While nosing about, the rabbit momentarily presents its side to the snake and like a flash the deed is done. The human eye can observe but two things: first, the snake appeared to strike at the rabbit, and secondly, to have barely touched it with its jaws. The snake is back in the original position before the rabbit's frightened squeal is over. The little creature bounds forward, rolls on its side, kicks convulsively, and is dead. Barely 1 minutes passes from the time of the serpent's strike to the termination of the death struggle.

e. Breeding. An average of 9 or 10 living young are born in August or September. They are about 14 inches (35.6 cm) in length.

f. Habits. This snake is chiefly terrestrial in its habits, as are all of the *Crotalus* species, but it is also somewhat arboreal, seen occasionally in low, scrubby bushes. It is also aquatic because it takes to the water, even crossing salt water among the nearby keys of Florida. It may even be seen a few miles out at sea, swept there by the outgoing tides. The pygmy rattlesnake and the massasaugas differ from the Crotalus species in that they are smaller in size and thus have proportionately smaller rattles, that they have nine large symmetrical shields or plates on top of the head similar to the other pit vipers (copperheads and water moccasins), and that they inhabit a damper habitat. The poison of some pygmy rattlers is actually more toxic, drop for drop, than venom of the larger species.

Exercises (822):

1. Match column A with Column B.

Column A *Statements*	*Column B* *Family Crotalidae*
____ 1. At least one species is found in every State except Alaska and Hawaii.	a. Water moccasin.
____ 2. The inside of the mouth is white.	b. Copperhead.
____ 3. Crossbands on the body appear as hourglasses from the top and as inverted Ys from the side.	c. Rattlesnake.
____ 4. They are sluggish and irritable; will drop quickly into water; and retreat to high ground in the fall.	
____ 5. Have horny interlocking joints at the end of the tail.	
____ 6. The largest and most deadly poisonous reptile found in the US.	
____ 7. Found from the swamps of Virginia through Florida, along the Gulf States to Texas, extends through eastern Oklahoma, Arkansas, Mississippi, southern Illinois, Indians, and Tennessee.	
____ 8. Feeds on frogs, fish, other snakes, birds, small mammals, lizards, small turtles, baby alligators, and salamanders.	
____ 9. Mates in April or May. Give birth to from 6 to 12 brilliantly colored young with sulphur-yellow tails.	
____ 10. Feeds on small mammals, birds, other snakes, frogs, and insects.	

2. The head of the pit viper is (round/flat) ________.
3. Pit vipers strike their prey and inject a (small/large) amount of toxic venom. ________
4. Pit vipers have pits on their (heads/bodies) ________.
5. The sidewinder rattlesnake thrives in (swamps/deserts) ________.
6. The eastern diamondback rattlesnake is the (smallest/largest) and (least/most) deadly reptile found in the US ________.

823. Indicate whether given statements concerning the Elapidae snake family are true or false, and correct those that are false.

Family Elapidae. With the exception of the coral snakes, this family inhabits chiefly Asia, Africa, and the Malay Archipelago. Two of its more formidable family members are the black mamba of Africa, the males of which actually go out of their way to attack humans during the breeding season, and the king cobra, which has frequently caused as many as 20,000 deaths yearly in India.

The Elapidae family contains two species of coral snakes found in this country *(Micrurus* and *Micruroides)* which differ from many of their family relatives by the "hood" apparatus which the cobra has. The coral snake grasps its prey by the neck or body and rapidly chews the poison in; considerable venom is injected and the prey is thus weakened for the swallowing process. The coral snake holds on and the fangs are worked along the body until the prey is shifted into a position from which it may be swallowed head first.

Description. These snakes are smooth, shiny, and cylindrical. The body is ringed with bands of red and black with more narrow bands of yellow. The snout is black with the black rings bordered with yellow and the colors red and yellow touching. The venom-conducting apparatus consists of short, stout, always erect, and immovable fangs on the forward part of the upper jaw. The pupil of the eye is round and the head is the same size as the neck.

Distribution. *Micrurus* is found from North Carolina south through Florida, westward to Texas, and northward up the Mississippi to Indiana. *Micruroides* is found in Arizona and New Mexico.

Habitat. These snakes, which average 2 to 2½ feet (60.76 to 76.2 cm), are secretive and sometimes burrowing, found commonly under the bark of decaying logs. They spend the majority of their lives in such places but frequently come out after heavy rains in search of food.

Food. These snakes feed chiefly on small snakes and lizards.

Breeding. In contrast to the pit vipers, they are oviparous, laying up to seven elongate eggs in decaying bark or damp soil. Little else is known about their breeding habits.

Habits. They are seldom encountered because of their secretive habits, but they are sometimes handled by children and other people (through ignorance of their poisonous properties) because of their attractive coloration and unoffensive nature. They rarely bite but are extremely dangerous. These snakes do not strike, as do the pit vipers, but grab their prey and *chew* the venom in. Their venom is also different from that of the pit vipers. The coral snakes have a neurotoxic venom which attacks the nervous system and the thoracic muscles, especially those of the diaphragm, so that breathing is difficult. The poison of the pit vipers is hemotoxic and effects the tissue and the red blood cells.

Exercises (823):

Identify the statements as true or false, and correct the false statements.

___ 1. Coral snakes have a hemotoxic venom.

___ 2. The males of the black mamba of Africa go out of their way to attack humans during the breeding season.

___ 3. The cobra and coral snakes are from different families.

___ 4. The king cobra has caused as many as 20,000 deaths yearly in India.

___ 5. Coral snakes have a "hood."

___ 6. Coral snakes are smooth, shiny, and cylindrical.

___ 7. Micruroides is found in New York and New Mexico.

___ 8. Coral snakes average 2 to 2½ feet in length.

___ 9. Coral snakes are usually found in open spaces sunning themselves.

___ 10. Coral snakes lay eggs.

824. List the symptoms of pit viper envenomization and the signs of coral snake envenomization.

Symptoms of Snakebite. The following outline of signs (what another person can observe) and symptoms is divided according to the snake family causing the poisoning.

Envenomization by pit vipers:

a. Presence of one or more fang puncture wounds (fig. 1-4).

b. Prompt and progressive swelling.

c. Pain.

d. Ecchymosis (bruiselike discoloration).

e. Nausea and vomiting.

f. Bleeding from the fang punctures.

g. Blister formation.

h. Respiratory and visual difficulties.

i. Shock.

j. Local necrosis (decay of tissue), often severe.

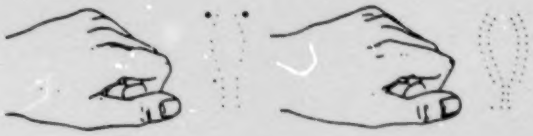

Figure 1-4. Snakebites.

Envenomization by coral snakes:

a. Presence of fang puncture wounds.

b. Blurring of vision.

c. Ptosis (drooping of eyelids), unsteady gait.

d. A feeling of thickened tongue and throat, slurring of speech, and tingling sensations.

e. Soft tissue swelling at the puncture point.

f. Drowsiness, lassitude.

g. Nausea and vomiting.

h. Excessive salivation and sweating.

i. Burning pain at the site of injury (pain and swelling occasionally may be absent in the presence of envenomization by certain elapids).

Exercises (824):

1. List the symptoms of pit viper envenomization.

2. List the signs of coral snake envenomization.

825. Identify given statements pertaining to the treatment of snakebite as being true or false, and correct the false statements.

Treatment of Snakebite. In the course of your work, you may be required to enter snake-infested areas. Never enter such an area alone. Follow the approved practice of proceeding in groups of at least two or three individuals. If you or one of your company are bitten in spite of precautions, you should seek professional medical attention at once.

If you can get professional medical treatment within an hour after the time of the bite, you should disregard extensive first aid. Keep calm and proceed for treatment.

In the event that you are snakebitten and first aid is required, there are a few rules you should bear in mind:

(1) *Keep calm.* Excitement stimulates the flow of blood and shortens the length of time required for the venom to reach vital organs.

(2) *Identify the snake, if possible.* Its identity is necessary before specific antivenin treatment can be given. If you are the victim, don't spend more than a few minutes at this activity and don't move more than a few feet away. Remember, DO NOT stimulate blood flow unnecessarily. If you are able to kill the snake immediately, check for fangs in the snake. Also, check for fang marks at the site of the bite. See figure 1-4. If the snake is poisonous, swelling occurs rapidly. The skin becomes a dark purple and ordinarily two puncture ppoints, made by the fangs, are seen clearly, as shown on the left in figure 1-4. Sometimes only one puncture mark appears. Scratches accompany the puncture wounds. Nonpoisonous snakebites, shown on the right in figure 1-4, appear only as scratches.

(3) *Immobilize the bitten part* in a position below the level of the heart.

(4) *Apply a constricting tourniquet.* Put it 2 to 4 inches closer to the heart than the site of the bite. Reapply the band ahead of the swelling if it progresses up the arm or the leg. If the snake is positively identified as a viper (rattler, moccasin, or copperhead), apply the tourniquet tight enough to occlude venous return flow. Be sure you have a pulse below the tourniquet. Release the tourniquet 1 minute every 30 minutes.

(5) If you are giving first aid to another person whose breathing fails, *administer mouth-to-mouth* or *mouth-to-nose artificial respiration.* Obtain assistance from the nearest medical source at the earliest possible moment.

(6) Make incisions and begin suction as soon as possible. You should take this step preferably within 10 minutes, but not after 1 hour following the bite. You should perform this procedure only when the snake is identified as poisonous or when swelling, pain, and other symptoms, as listed previously, have developed and you cannot reach the services of a doctor within an hour. Here are the general rules for incision and suction treatment:

a. Sterilize a sharp instrument.

b. Make the cuts through the fang marks parallel to the long axis of the limb and deep enough to allow free bleeding. Cuts should be about ¼ inch deep and ¼ inch long. Do not make crosscut incisions. The incision must penetrate the skin but not enter muscles or underlying structures (tendon, blood vessels, or nerves). NOTE: You should never make incisions on fingers, hands, wrists, toes, feet, or ankles unless it is extremely necessary or the part is so swollen that such incisions cannot damage underlying structures.

c. Perform suction with suction cups or by mouth, spitting frequently, and continue for at least 30 minutes. (Snake poison is harmless in the mouth unless there is a cut there.) If you are the victim, you can do this yourself if you can reach the fang marks with your mouth.

d. Get medical help as soon as possible.

Most antivenins produced today are narrowly specific and neutralize only the venom that was used in their production. Relationship of the snake species (for example, using rattler antivenin for a copperhead bite) is not a safe criterion for judging the value of an antivenin in treatment.

Exercises (825):

Identify the statements as correct or incorrect, and correct those that are incorrect.

___ 1. Never enter snake-infested areas alone.

___ 2. Entomology personnel may administer antivenin.

___ 3. When treating for snakebite, institute incision and suction within 10 minutes but not after 2 hours.

___ 4. Snake poison is harmless to the mouth which has no cuts.

___ 5. Nonmedical personnel should never make incisions on fingers, hands, wrists, toes, feet or ankles unless the part is highly swollen.

___ 6. The best rules to follow when a worker is bitten by a snake are: help the victim keep calm, identify the snake and get medical help as soon as possible.

826. Complete given statements pertaining to the measures that may be used to control snakes.

Site Sanitation. Removing brush and woodpiles, keeping vegetation cut short, and trimming vines and brushes will eliminate harborage areas and will discourage snakes because this eliminates rodents from the area which are the food source of snakes. An effective rodent control program will aid immeasurably in controlling snakes.

Avoidance. The best personal protection against snakes is to avoid their natural habitats. If you must enter these areas, wear hip boots and make sufficient noise so that the snakes can get out of your way or at least warn you. Do not sit on logs or rocks until after you have made a thorough inspection.

You will probably be required to answer calls concerning the presence of snakes in or under various base facilities. In this event, you should wear hip boots and have a bright, reliable flashlight and a good set of snake tongs because you must inspect every area possible within the facility, including the attic and under the flooring, providing the facility is designed in this manner.

Chemical Control. The use of chlorinated hydrocarbon pesticidal dust has been proven somewhat effective for the control of snakes. When necessary, these chemicals can be used as barriers and in preparation of traps.

One foot wide barriers of dusts surrounding encampments and facility grounds are effective for discouraging snakes from entering the protected areas.

Traps constructed from dampened burlap sacks that contain chlorinated hydrocarbon pesticidal dusts can be placed in out of the way protected areas within or around a facility offers good control of snakes. The dampened burlap sacks attract the snakes and they are poisoned as they lay upon them.

Exercises (826):

1. An effective ______________ control program will aid immeasurably in controlling snakes.
2. The best personal protection against snakes is to ______________ their natural habitats.
3. The use of ______________ hydrocarbon pesticidal ______________ has been proven somewhat effective for the control of snakes.
4. As an Entomology specialist looking for snakes under buildings, you should wear ______________ ______________ and a have a bright reliable ______________ .
5. Traps constructed from dampened ______________ ______________ can be placed in out of the way protected areas.

CHAPTER 2

Household Pests

HOUSEHOLD PESTS rob the citizens of the United States of millions of dollars each year, contaminating and spoiling far more than they eat. When present in a restaurant or store, they repel customers and cause economic loss. They damage clothing, rugs, and other items. They cause disease in and transmit disease to people and their domestic animals. In your job, you should be able to recognize common household species, know their public health importance, and be able to recommend effective control procedures.

2-1. Cockroaches

Cockroaches (order Dictuoptera, family Blattidae) form the oldest group of insects. They are among the most persistent pests and exhibit a high degree of adaptability. Although many species live outdoors, others have moved indoors and have become among the most widely distributed and most numerous of pests.

This section covers the cockroach species that are considered to be important household pests, the life history and habitats of these pests, and the controls that can be used to manage them.

827. State the importance and give the general identifying characteristics of cockroaches.

Importance. Cockroaches are the most important household pests infesting homes, hotels, restaurants, bakeries, and many other food serving establishments. Cockroaches have become well-adjusted to living with man. They harbor in the cracks and crevices provided by human buildings. They subsist on the bits of food scattered where humans live or travel. Cockroaches have been reported nibbling on the eyelashes, fingernails, and toenails of sleeping children. They impart an unsavory odor and taste to food they infest. Cockroaches prey on bedbugs. They carry the organisms causing enteric diseases (diarrhea, dysentery, typhoid, food poisoning) from sewers and garbage cans to the food of humans. The rat tapeworm *(Hymenolepis diminuta)* can be picked up by cockroaches (as well as by mealworms, fleas, and other arthropods) and then transmitted to humans through the insect's fecal material. This disease is not considered serious because of the limited number of human cases, the cockroach in its transmission can be considered minor.

General Characteristics. Cockroaches (fig. 2-1) undergo gradual metamorphosis and progress through nymphal stages to the adult. There are about 55 species in the United States, but only 5 are common pests indoors.

Most species possess wings. When present, there are two pairs with the front pair usually being long, narrow, opague, and leathery. Cockroaches have chewing mouthparts and can usually be recognized by their oval, flattened shape, the head concealed under the pronotum, and the long bristlelike antennae.

These insects are live in groups and are active at night. They prefer warm, damp, secluded hiding placing during the daytime, such as electrical panel boxes, refrigerator insulation, sink cabinet, drain pipe areas, furnace rooms, sewers, food service equipment, cracks and crevices of floors, walls and furniture.

The eggs of cockroaches are inclosed within purselike capsules called oothecae, which may contain from 12 to 50 eggs, depending on the species. The eggs are contained in two rows of divided chambers. The female often carries the ootheca protruding from the end of the abdomen for several days before dropping it or gluing it to a surface.

The tiny white nymphs that emerge from the eggs closely resemble the adults. They go through successive periods of growth separated by molts and form the adults.

Exercises (827):

Complete the following statements.

1. Cockroaches are the most important household pests, infesting ________, ________, ________, and ________.
2. They harbor in ________ and ________ provided by human buildings.
3. They subsist on the ________ of ________ man scatters where he ________ or ________.
4. Cockroaches are ________ on bed bugs.
5. They carry the organisms causing enteric diseases (________, ________, ________, ________ ________) from sewers and garbage cans to the ________ of man.
6. The rat tapeworm can be picked up by cockroaches, as well as by ________, ________, and other arthropods.

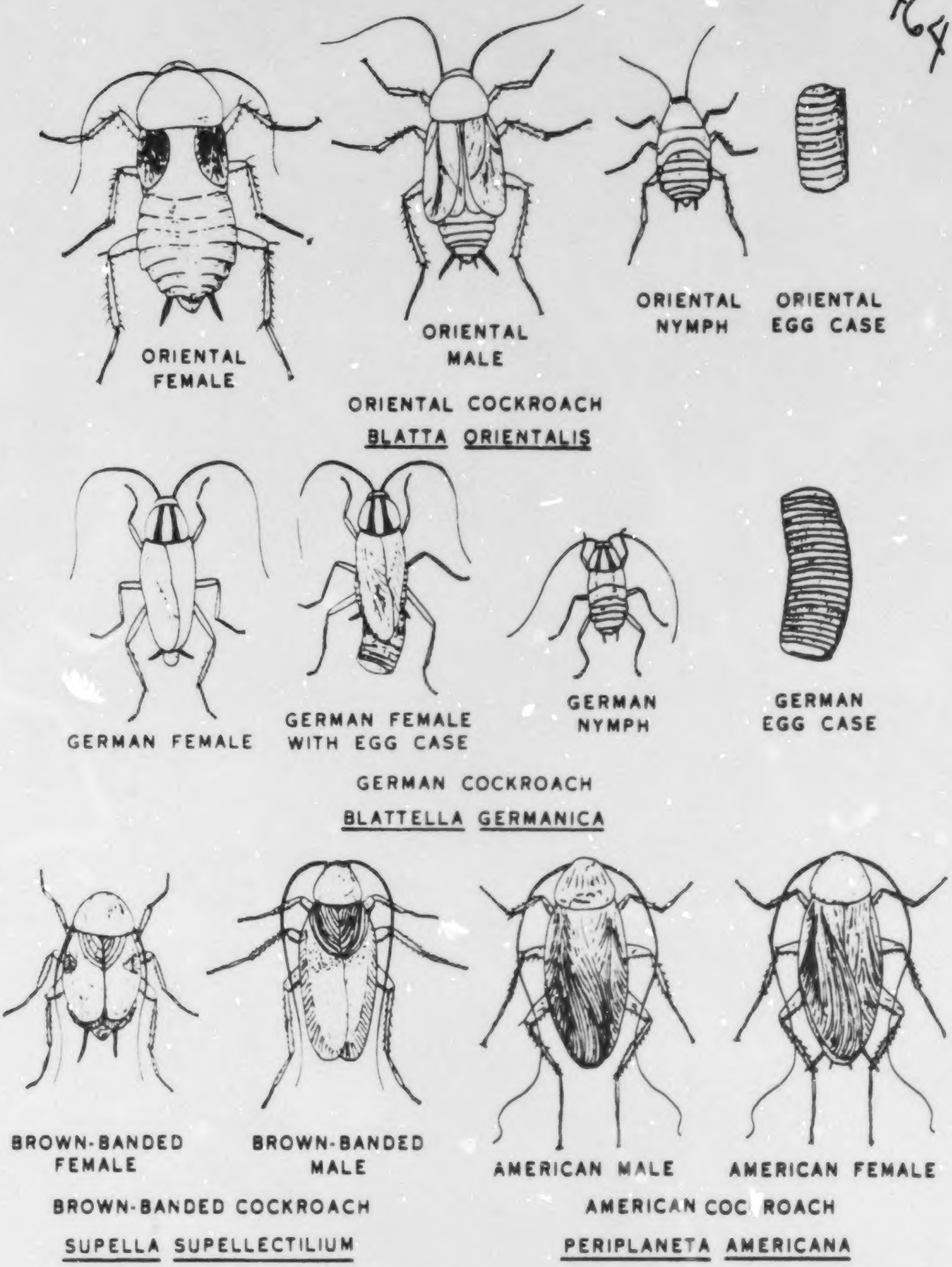
ORIENTAL FEMALE
ORIENTAL MALE
ORIENTAL NYMPH
ORIENTAL EGG CASE
ORIENTAL COCKROACH
BLATTA ORIENTALIS
GERMAN FEMALE
GERMAN FEMALE WITH EGG CASE
GERMAN NYMPH
GERMAN EGG CASE
GERMAN COCKROACH
BLATTELLA GERMANICA
BROWN-BANDED FEMALE
BROWN-BANDED MALE
AMERICAN MALE
AMERICAN FEMALE
BROWN-BANDED COCKROACH
SUPELLA SUPELLECTILIUM
AMERICAN COCKROACH
PERIPLANETA AMERICANA

Figure 2-1. The cockroach.

7. There are about ______________ cockroach species in the United States.
8. These insects live in groups and are active ______ ________ and prefer __________, __________, ______________ hiding places during the other part of the day.
9. The eggs of cockroaches are inclosed within a purselike capsule called ____________ .
10. The tiny white __________ which emerge from the eggs closely resemble the ____________ .

828. Relate given cockroach species to their identifying characteristics.

The five most important indoor cockroaches are the:

- German.
- Brown-banded.
- Oriental.
- American.
- Australian.

German Cockroach. The German cockroach *(Blattella germanica)* may also be known as the "water bug" or "croton bug" and is the most active, widely distributed, and serious household cockroach.

Both sexes are fully winged and very similar in size (approximately 13 mm long) and coloration (pale brown body with two parallel, longitudinal, black stripes on the pronotum). The small nymphs are black with a tan stripe down the middle of the pronotum extending from behind the head onto the base of the abdomen. See Appendix B, in a separate inclosure.

This cockroach is abundant in kitchens, bathrooms, and pantries. The most common way for it to enter buildings is with onions, potatoes, and bottled drinks.

The German cockroach has a relatively short developmental period, lasting from 2 to 4 months. The ootheca is yellowish and contains 30 to 40 eggs and is almost as large as the abdomen of the female. It is carried by the female at the end of her abdomen until a day or so before hatching occurs. This egg-carrying process is accomplished only by this species.

Brown-Banded Cockroach. The brown-banded cockroach *(Supella supellectilium)* is one of the most difficult cockroaches to control because it does not confine its activities to the kitchen and pantry, but may be found throughout the building.

The brown-banded cockroach resembles the German cockroach but is slightly smaller. It has two light brown crossbands, one at the base of the forewings and one 1.5 millimeters further back.

The males and females are so different in general appearance that they are commonly identified as two different species of insects. The male is longer, more slender and a lighter or yellowish-tan color with the wings longer than the abdomen. The female is shorter, more heavily-bodied, and dark brown in color. Her wings do not extend beyond the abdomen. You can see these differences in Appendix B, page B-13 (in a separate inclosure).

The nymphs are usually more clearly "brown-banded" than the adults. They have a light transverse band on the thorax and a similar band on the abdomen.

The brown-banded cockroach can be found anywhere in a building. It may be found in a desk drawer or behind a picture frame. Besides feeding on foodstuffs, it feeds upon the glue on postage stamps, sizing in books, wallpaper paste, and other articles not normally considered to be food.

The ootheca is shorter than that of the German cockroach. It is about 4.6 mm long, usually yellowish or reddish-brown in color. It turns green when the eggs are near development. There are usually 18 eggs per capsule, 13 of which generally hatch.

Oriental Cockroach. The Oriental cockroach *(Blatta orientalis)* is one of the filthest cockroach species because of its prevalence in sewer lines, damp and dirty basements, and other unsanitary places.

This cockroach is dark brown or black and is from 2.5 to 3.2 mm long. The male is slightly shorter and narrower than the female and bears shortened, truncated wings which cover one-half to three-fourths of the abdomen. The female has only short, oval wing pads as shown in Appendix B (in a separate inclosure).

Immature stages are entirely dark-brown or black and are similar to those of the American cockroach. They lack the fleshy pad *(arolia)* between the tarsal claws which is present in all stages of the American cockroach.

This cockroach is found abundantly in kitchens and pantries. It is also fond of warm, damp basements, areas containing steam and water pipes, sewer systems, and theaters.

The female carries the dark reddish-brown egg capsule for only 30 hours before depositing it. The capsule contains approximately 16 eggs.

American Cockroach. The American cockroach *(Periplaneta americana)* is the largest of the five major cockroaches and is one of the filthiest along with the Oriental cockroaches. It is a large (3.8 cm) reddish-brown cockroach with both sexes having well-developed wings which extend beyond the length of the abdomen. *Only the male has cerci and styli.* It has a pale area surrounding the pronotum. See Appendix B (in a separate inclosure).

The first stage American cockroach nymph has entirely dark antennae. The later American cockroach nymphal stages have an entirely dark abdomen. Indoors, this cockroach may be found in warm places, such as sewer systems, basements, and steam tunnels. During the warm months it can be found in such places as trees, dumps, outbuildings, and woodpiles. This species causes extensive damage to book bindings, manuscripts, clothing, labels, and foods intended for human consumption.

The ootheca of the American cockroach is reddish-brown, and is about 1½ times as long as wide. It contains about 14 eggs which require a 2-month incubation period. All of the eggs are deposited within the ootheca in about a 24-hour period, after which the capsule may be dropped at random or attached to some surface.

Australian Cockroach. The Australian cockroach *(Periplaneta australasiae)* is a less serious pest than the four previous species.

This cockroach is slightly smaller than the American cockroach, being slightly less than 2.5 mm long with a vivid pale area surrounding the edge of the pronotum. The front wings have an outer pale streak at the base. See Appendix B (in a separate inclosure). Both sexes are fully winged and similarly marked.

The nymphs are strikingly marked with yellowish spots on the thorax and abdomen. This cockroach is commonly found inside of buildings as well as out of doors. In cold weather it frequently is abundant in heated buildings, such as greenhouses.

The ootheca contains approximately 25 eggs. The hatching nymphs will molt about nine times before maturity.

Exercises (828):

1. Match the cockroach species in column B with the identifying characteristics in column A.

Column A

Characteristics

___ a. Most active, widely distributed and serious household cockroach.
___ b. Largest and one of the filthiest.
___ c. Feeds upon glue on postage stamps, sizing in books, wallpaper paste, and other articles not normally considered to be food.
___ d. Less serious pest than the other four.
___ e. Lack the fleshy pad between the torsal claws.

Column B

Species

1. American.
2. Oriental.
3. Australian.
4. German.
5. Brown-banded.

829. State the methods you can use to control cockroaches.

Physical Preventive Controls. Because of cockroach habits, good sanitation is imperative in achieving and maintaining good control. In the absence of reasonably good sanitation, chemical control measures cannot be fully effective.

You must remove all food scraps and residues, including greasy films, as a basic procedure in cockroach control. Do not limit such sanitation measures to food facilities. Significant infestations can develop around vending machines and adjacent refuse containers which receive empty milk cartons, ice cream bar wrappers, and similar packaging. These containers invariably retain a food residue.

Food should be kept in closed containers to reduce availability to cockroaches although the primary consideration here is preventing contamination.

Whenever practicable food and containers particularly susceptible to cockroach infestation should be checked outside before they are brought into homes, hotels, and food-serving establishments.

Water should not be allowed to run or seep into harborage areas where it will maintain humidity conditions favorable for cockroaches.

Proper design of structures and food service equipment and placement of equipment is important in reducing harborage and in making sanitation easier. Partitions and counters and other building modifications often give excellent harborage for cockroaches. Food service equipment should be designed and installed to minimize areas in which food residues tend to accumulate and to make thorough cleaning as easy as practicable under limiting space and other conditions.

Chemical Control. In households pesticides should be applied as a spot treatment, using a coarse spray or a dust to treat along baseboards and water pipes, in cabinets, under refrigerators, and behind stoves. Staining problems may arise in treating certain types of surfaces. Be careful when you spray oil-base solutions around asphalt or vinyl tile floors. Spillage on surfaces of this type causes a softening and surface-marring effect.

Studies have shown that the activity of insecticidal residues is markedly influenced by the type of material to which the formulation is applied. Compounds that are somewhat volatile persist longer on painted metal surfaces than on unpainted metal, whereas the reverse may be true with other toxicants.

For controlling cockroaches in dining facilities, pin-stream spray insecticides into cracks and crevices in walls, baseboards, furniture, fixtures, cabinets, and other places where cockroaches hide. Blow dust into dead spaces, or on electric wires, fuse boxes, and other items which sprays might damage.

Several compounds are available for use as baits. The speed of kill and the length of activity vary with the insecticide.

Dust applications offer an advantage over liquid treatments in that they give better penetration of inclosed areas, such as beneath cabinets and in wall voids. They are not normally used in visible areas because of their unsightly appearance. The drift qualities of dust enable them to be used in any area that is difficult to spray. A disadvantage, however, is that cockroaches tend to avoid dust deposits. Certain dusts containing fluoridated silica aerogels are reported to act as a desiccant as well as a repellant to cockroaches.

The use of aerosol formulations in combination with a residual spot treatment is of value in flushing the insects from protected recesses and obtaining quick kills in heavy infestations. The residual treatment should precede the aerosol application. In other instances, the application of the spot treatment together with baits may be more effective than either application alone.

Of the various species of cockroaches associated with humans, the German cockroach, *Blattella germanica*, is of greatest significance not only because of its widespread distribution but also because it alone has shown the ability to develop resistance to many of the insecticides used for cockroach control. Since the detection of resistance to chlordane in this species in 1953, the organophosphorus insecticides have been routinely used for its control. However, during the past decade populations resistant to diazinon, fenthion, and malathion have been detected in several parts of the United States. Resistance to malathion appears to be specific but that to diazinon extends to related chemicals. Recently, a strain slightly resistant to propoxur (Baygon), a carbamate, was reported from Louisiana. Despite the occurrence of organophosphorus-resistant populations in certain localities, such resistance has not, as yet, created a widespread control problem.

Exercises (829):

Complete the following statements concerning the methods of controlling cockroaches.

1. Because of cockroach habits, ______________ ______________ is imperative in achieving and maintaining good control.
2. In the absence of reasonably good sanitation, ______________ control measures cannot be expected to be fully effective.
3. The wide variety of food acceptable to cockroaches makes removal of ______________ ______________ and ______________, including ______________ ______________, a basic procedure in cockroach control.
4. Significant infestations can develop around ______________ machines.
5. Food should be kept in ______________ containers to reduce availability to cockroaches.
6. In households, pesticides should be applied as a ______________ treatment, using a ______________ spray or a ______________ to treat baseboards.
7. Caution should be used when spraying oilbase solutions around ______________ or ______________ tile floors.
8. Dust applications offer an advantage over ______________ treatments in that they give better ______________ of inclosed areas.
9. Dusts are not normally used in ______________ areas because of their ______________ appearance.
10. The use of aerosol formulations in combination with a ______________ spot treatment is of value in flushing insects from protected ______________.
11. The German Cockroach has shown the ability to develop a ______________ to many of the insecticides used for cockroach control.

2-2. Silverfish and Firebrats.

Although these insects are not nearly as important as the cockroaches, they do become severe pests in many homes and other facilities at times.

This section will give you information pertaining to their importance, characteristics, and the controls that can be employed against them.

830. Determine whether given statements correctly reflect the importance and the characteristics of silverfish and firebrats.

Importance and Characteristics of Silverfish and Firebrats. Besides the fact that these insects are annoying, they attack such materials as book bindings, photographs, wallpaper, labels, and the sizing of any of these paper products. They also attack starched clothing, linen, rayon, cereals, and grain. In spite of their prevalence and constant close association with humans, silverfish and firebrats do not appear to be vectors of any human diseases.

The silverfish and firebrats (order Thysanura, family Lepismatidae) are the commonest forms of the most primitive insects. They are small (19 mm long), carrot shaped, fast moving, wingless insects with long antennae. The abdomen of these insects is long and bears three appendages (a pair of *cerci* and a median caudal *filament*) on the posterior end. The color of the silverfish is a uniform glistening silver, while the firebrat is grayish and mottled with dark markings.

Silverfish and firebrats exhibit little or no metamorphosis, the young looking very much like the adults. Development of the common silverfish *(Lespisma saccharina)* requires about 12 weeks from egg to adult. Silverfish range far from their hiding places at night in search of food, and will quickly infest an entire building. They harbor where food and moisture can be readily obtained. Firebrats harbor under hot, dry conditions, such as behind stoves or around fireplaces.

Exercises (830):

Identify the statements below as correct (C) or incorrect (I) and correct the false statements.

___ 1. Silverfish and firebrats attack book bindings, photographs, wallpaper, labels, and sizing of paper products.

___ 2. They also attack cereal and grain but not clothing.

___ 3. Silverfish and firebrats do not seem to be vectors of any human diseases.

___ 4. Silverfish and firebrats are the commonest forms of the most primative insects.

___ 5. Silverfish have two sets of wings while firebrats have only one set.

___ 6. Silverfish and firebrats sometimes infest entire buildings.

831. State the control measures that can be implemented in managing silverfish and firebrats.

Exercise the same care in controlling silverfish and firebrats in homes, domitories, bakeries, and dining facilities as you would in controlling cockroaches.

Physical Control. Silverfish and firebrats can be controlled to some extent by inspecting furniture, carpets, and other cloth goods before placing them within a facility, especially those items that have been stored or shipped during transfers.

Reducing food supplies to the least amount practicable may be of some benefit in preventing damage. Physically excluding these arthropods from stored susceptible fabrics will prevent infestations.

Chemical Control. Silverfish and firebrats can be controlled by applying residual insecticide emulsions (see Appendix A, in a separate inclosure, for recommended chemical and application methods and rates) to cracks and crevices and behind furniture. Give special attention to the basement, attic, closets, ovens, and around bookcases. A good cockroach control program will normally control silverfish and firebrats.

Exercises (831):

1. A good ____________ control program will normally control silverfish and firebrats.
2. Silverfish and firebrats can be controlled to some extent by inspecting __________________, and other ______________ goods before placing them within a facility.
3. To control silverfish using malathion, apply as a ____________ spray or apply with a ______ brush to ____________, surfaces behind and beneath ____________, ______________, ______________, ______________, and similar areas where insects hide.

2-3. Bedbugs

The common bedbug has been a pest of humans since prehistoric times and has spread to most parts of the world. This insect has been prevalent in Europe for centuries and has been in this country since the early colonial days although, it apparently was unknown to the American Indian. The bedbug gains access to living quarters in traveling bags and laundry or by migration. It is frequently transferred from person to person in transportation facilities.

This section: (1) identifies the bedbug and its importance, (2) describes its characteristics, (3) relates its life history and habits, and (4) names the controls that can be employed against bedbugs.

832. Describe the bedbug's appearance and its relationship with people.

Identifying Characteristics. The adult bedbug (fig. 2-2) is approximately 5 mm long, 3 mm wide, and reddish brown in color. The flattened oval body is adapted for hiding in narrow crevices. The head bears a pair of four-segmented antennae and piercing-sucking mouthparts which fold to lie between the first pair of legs. The wings are represented by pads. The body may become greatly enlarged and blood red during the taking of a blood meal. The bedbug belongs to the order Hemiptera and the family Cimicidae.

Relationship with Humans. Both sexes of the bedbug feed on mammalian (any of the highest class of vertebrates) blood, particularly that of humans. Bedbug bites differ from flea bites because they don't leave a red spot surrounded by a circular reddish area fading into the normal skin as does the flea. Bedbugs have not been proved to be an important disease bearer, but heavy infestation can lead to human nervous and digestive disorders. The two species of bedbugs that attack humans are the *Cimex lectularius* and the *Cimex hemipterus,* the first one being predominant in temperate regions and the second being predominant in tropical regions.

Exercises (832):

1. What are the size and color of the normal adult bedbug?
2. What is the appearance of the bedbug during a blood meal?
3. What sex and species attack humans?
4. What effects do bedbug bites have on humans?

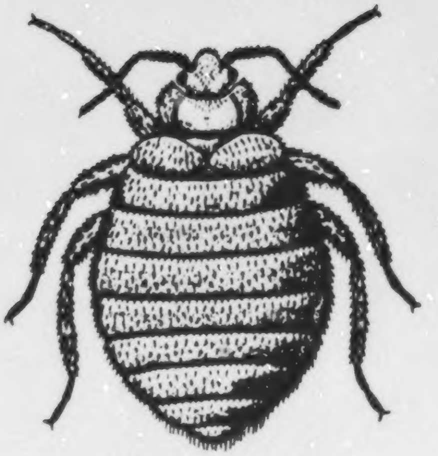

Figure 2-2. The bedbug.

833. State the general habits and describe the development of bedbugs.

Habits. Bedbug-infestation can be detected by the characteristic buggy odor, blood stains on sheets, and fecal stains along crevices. This insect is very seldom seen during the daytime because of its nocturnal habits.

Development Bedbugs develop through a gradual metamorphosis. The female lays very few eggs until she has had a meal of blood. Generally, a single blood meal is sufficient for each instar or nymphal stage after the first. She lays from 1 to 5 eggs daily for a period of 2 months or until approximately 200 eggs are deposited. Complete development from egg to adult takes from 18 to 56 days (depending on the temperature). The adult lives from 6 to 12 months. The female can live nearly a year without food and can endure freezing temperatures for varying periods of time.

Exercises (478):

Complete the following sentences.

1. Bedbug infestation can be detected by the characteristic ______________ ______________, ______________ stains on sheets, and ______________ stains along crevices.
2. The time of day bedbugs are usually seen is ______________.
3. Bedbugs develop through a gradual ______________.
4. The female bedbug lays very few eggs until she has had a ______________ of ______________.
5. Complete development from egg to adult takes from ______________ to ______________ days, depending on the ______________.
6. The adult bedbug lives from ______________ to ________ months.
7. The female can live merely a ______________ without ______________ and can endure ______________ temperatures for varying periods of time.

834. Give appropriate bedbug management techniques.

Control of Bedbugs. You can effectively control bedbugs in living quarters by applying an approved insecticide emulsion (see Appendix A, in a separate inclosure, for chemicals to use and read insecticide label) to infested mattresses, pillows, bedsteads, baseboards, furniture, crevices, and behind doors and window frames. One application of an approved chemical solution should control bedbugs for more than a year. The bedbug is so susceptible to insecticide poisoning, that it is possible to eliminate the pest from living quarters and other places. Fumigation and other types of treatment are unnecessary. The control of bedbugs has changed from a major problem to a very minor one.

When you are preparing to spray quarters, remove the clothing, rubber material, gas masks, and other objects that you must protect from kerosene. Do not remove bedding or other items that may be infested, because the bedbugs may be transferred in them to a new location. For good results when spraying, follow the steps outlined below:

a. Move beds away from the wall to permit spraying the wall surfaces.

b. Fold mattresses and place in the center of the bed at an angle of 45°.

c. Open windows for ventilation before starting spray operations. Apply residual spray at a rate of 1 gallon to 1,000 square feet of area. Use the standard 2-gallon sprayer with a fan-spray nozzle and a pressure of 30 to 40 psi. Apply the spray to point of runoff without filling the air with a foglike mist.

d. With a two-man crew, begin at one end and work around the room, spraying cracks, wall beams and braces, and other places likely to harbor bedbugs. Spray to a height of about 4 feet from the floor for single beds and 6 feet if double-tier beds are used.

e. Spray one end of the bed, including the coils and covers, and one folded edge of the mattress. Return up the opposite side and spray the bed, coils, corners, and mattress edges. Observe all recommended safety precautions when spraying.

Exercises (834):

Identify the following statements concerning bedbug controls as correct (C) or incorrect (I).

___ 1. The control of bedbugs is a major problem.
___ 2. When spraying for bedbugs, remove only items which are not infested.
___ 3. Move beds away from walls to permit spraying of wall surfaces.
___ 4. Leave mattresses flat when spraying.
___ 5. Keep windows closed to prevent the escape of the insecticide.
___ 6. Apply a residual spray at the rate of 1 gallon to 1,000 square feet of area.
___ 7. Spray to a height of 4 feet for single beds and 6 feet for double-tier beds.

2-4. Crickets

As an entomology specialist you will be required to rid base facilities of crickets at various times. Thus, you must know the identifying characteristics and habits of these insects.

835. Relate common cricket species to descriptive statements.

Identification and Habits of Crickets. Crickets belong to the order Orthoptera. They have biting mouth-parts, long legs fitted for jumping, and may have wings when full grown. They develop by gradual metamorphosis, going from the egg through a series of nymphal instars to the adult. The adult male produces the familiar chirping sound by scraping his upper wings together.

The house cricket *(Acheta domestica)*, is found throughout the United States. This shiny, black insect is fond of warmth and often becomes troublesome in bakeries and homes. In warm weather, it lives out of doors, especially in garbage dumps, and enters the home chiefly in cold weather. They may be numerous in newly constructed homes. Cave and camel crickets occur throughout the world. They are usually wingless and have antennae that may be four or five times as long as the body. These large nocturnal insects are usually brown or gray and may be found in outbuildings or basements. They apparently do little, if any damage. Jerusalem crickets *(Stenopelmatus fuscus)* are large, clumsy insects with but heads. Many people in the southwestern United States believe they have a venomous bite, but they are harmless.

Excercise (835):

1. Match the cricket species in column B, with the descriptive statements in column A.

		Column A		*Column B*
____	1	Large clumsy insects with big heads.	a.	Jerusalem cricket.
____	2.	Fond of warmth and is often troublesome in bakeries and homes.	b.	House cricket.
____	3.	Antennae may be four or five times as long as the body.	c.	Cave and camel crickets.
____	4	Many people believe they have a venomous bite.		
____	5	Usually brown or grey.		
____	6	Enters the home chiefly in cold weather.		

836. State what controls you can use against crickets.

Control of Crickets. Crickets may be effectively controlled by applying approved insecticides indoors as residuals (see Appendix A, in a separate inclosure, for recommended chemicals). These residuals may be applied to floors, walls, ceilings, and other areas, such as in and around fireplaces and dark crevices, in basements, and behind baseboards. Treatment in food facilities must be restricted to cracks and crevices. The formulation can be applied to surfaces by spraying or brushing.

Baits can also be used indoors for controlling crickets by placing the baits in areas where crickets are numerous and tend to congregate.

To prevent crickets from entering buildings, residuals can be sprayed in a 5-foot band on soil around the structure and on the foundation wall to a height of 2 to 3 feet.

You must use your chemicals in accordance with the recommendations provided on the pesticide label.

Exercises (836):

Complete the following statements concerning the controls for crickets.

1. Crickets may be effectively controlled by applying approved insecticides indoors as ____________.
2. These residuals may be applied to ____________, ____________, ____________, and other areas such as in and around ____________, ____________ ____________, ____________, ____________, and behind ____________.
3. Treatment in food facilities must be restricted to ____________ and ____________.
4. The formulation can be applied to surfaces by ____________ or ____________.
5. ____________ can also be used indoors for controlling crickets.
6. Baits are placed in areas where crickets are numerous and tend to ____________.
7. To prevent crickets from entering buildings, ____________ can be sprayed in a ______-foot band on ____________ around the structure and on the ____________ wall to a height of ________ to ________ feet.

2-5. Ants

Ants are among the most abundant of animals being found under both arid and humid conditions in the tropical, temperate, and upper temperate regions of the world. They feed upon every food consumed by humans and are troublesome household pests. You must be able to identify important ant species, know their habits, and be able to use the control measures that are effective in ant management.

837. Give the important aspects and general characteristics of ants.

Importance and General Characteristics of Ants. Some ants feed predominately on sweets, whereas others prefer meats and grease. Ants may be rare vectors of the organisms causing enteric diseases from feces or garbage to human food. All ants bite, and some ants sting. Reaction to ant bite or ant sting can be severe in sensitive individuals. Fire ants, which have a highly venomous sting, are a major problem in parts of the southeastern United States. Ants act as scavengers and predators of many harmful insects.

Ants are distinguished from other insects by having the first one or two abdominal segments reduced into a knobbed pedicel or stalk situated between the thorax and the abdomen proper, and by their elbowed antennae. The forewings of ants are larger than the hind wings and have comparatively few veins. Ants have chewing mouthparts, their heavy mandibles being suitable for biting, piercing, cutting, and gnawing. The smallest ant is less than 1.5 mm long, and the largest ant attains a length up to 3.8 cm.

Ant colonies may last many years, some of them longer than the years allotted to man. The colony is established when the newly mated female discards her wings, digs a nest, and produces eggs for a new brood. After nourishing her young through the larval stage, her labors are over as the larvae pupate and the young workers emerge and take over the work. The worker ants feed the queen, fight off all enemies, construct a maze of tunnels, and care for the young. When the colony has become strong, a special brood of males and females is reared to establish new colonies. These winged adults emerge for their marital flight in vast numbers in order to mate and seek new homes.

Exercises (837):

Complete the following statements concerning the important aspects and general characteristics of ants.

1. Some ants feed predominately on ____________, whereas others prefer ________ and __________.
2. Ants may be rare vectors of the organisms causing ____________ diseases from ____________ or ____________ to human food.
3. All ants bite, and some ants ________________.
4. Reaction to an ant bite or sting can be severe in ________________ individuals.
5. Fire ants, which have a highly ____________ sting, are a major problem in parts of the—United States.
6. Ants acts as ______________ and ____________ of many harmful insects.
7. The forewings of ants are ____________ than the hindwings.
8. Ants have ____________ mouthparts, their heavy ________________ being suitable for ____________, ____________, ____________, and ____________.
9. The smallest ant is less than ______________ mm long, and the largest ant attains a length up to ________________ cm.
10. Ant colonies may last many years, some of them longer than the __________ allotted to ________.
11. The worker ants ____________ the queen, fight off all enemies, construct a maze of ____________ and ______________ for the young.
12. When the colony has become strong, a special ______________ of males and females is reared to establish ______________ ________________.

838. Associate important ant species with their definitions.

Argentine Ant. The adult queen is approximately 5 mm long with the male being about half the size. The workers are approximately 2.5 mm long. These ants are brown.

This species is one of the worst house pests known throughout the Southern States and in some Northern States. It invades homes in hordes in search of sweets. Although it does not sting, it bites freely. The nests may be found outdoors in the open ground or beneath wooden objects. These ants will move indoors and possibly nest to seek warm dry areas to hibernate.

Pharaon Ant. The adult worker of this species is from 1.5 to 2 millimeters long. It varies in color from red to yellow and has three segments in the antennal club.

The pharoah ant feeds on sweets and greases. It is one of the most difficult species to control in the home because many colonies may exist in a single house. The pharaoh ant will nest in almost any secluded spot, but it prefers areas that are relatively warm.

Little Black Ant. This ant is jet black in color and is approximately 1.5 mm long.

The natural food of this ant is the honeydew that is derived from aphids and the sweet secretions of plants. However, it will invade homes readily in search of sweet foods. The nests of this species are found beneath rocks, in lawns, or in areas that are free of vegetation.

Thief Ant. This ant is one of the smallest (approximately 1.25 mm long). It is yellowish and has a two-segmented club antenna. This ant nests in exposed areas outdoors and under buildings. The thief ant feeds chiefly upon greasy substances, but it may feed on sweets. It is prevalent around sinks and cupboards.

Odorous House Ant. The odorous house ant worker is from 2 to 3 mm long. It is brownish to black in color.

This ant is widely distributed throughout the United States and is especially apt to invade buildings during rainy weather. It has an unpleasant odor when it is crushed. You must find the nesting site in order to control the odorous house ant. The nest may be in the woodwork of the building or under the subfloor near hot water pipes. This ant feeds principally upon sweets.

Fire Ant. There are many varieties of fire ants. The workers range in size from 1.6 to 5.8 mm long. They are brownish red, with a brown to black abdomen. The head and part of the thorax is usually yellowish in color.

Fire ants are so named because of their fiery stings. The most important species are the *imported fire ant*, the *southern fire ant*, and the *tropical fire ant*. Besides their ability to sting severely, these ants are important agricultural pests because of their foraging and mound building habits. The fire ants also injure livestock, wildlife, and crop workers.

The bite or sting of this insect produces a dermatitis and general toxic effect. Its venom, insecticidal and antibacterial, produces instantaneous paralysis of fruit flies, house flies, termites, weevils, and mites.

The nests of these insects are usually under stones, boards, in rotten wood, cracks in concrete, beneath houses, at the base of plants and tufts of grass, and especially near fire places. The average size of the nests found in the United States is an area of 2 to 4 feet in diameter.

The fire ant feeds upon greasy substances when indoors. It also gnaws on fabrics, especially dirty clothing.

Exercise (838):

1. Match the important ant species in column B with the statements in column A.

	Column A	*Column B*
____ 1.	One of the smallest of all ants and is yellowish in color.	a. Fire ant.
____ 2.	Varieties include imported, southern, and tropical.	b. Little black ant.
____ 3.	Has an unpleasant small when crushed.	c. Argentine ant.
____ 4.	Invades homes in hordes.	d. Odorous house ant.
____ 5.	Natural food is honeydew derived from aphids.	e. Pharaoh ant.
____ 6.	Difficult to control in the home since many colonies may exist.	f. Thief ant.

839. State how you can control ants.

Indoor Ant Control. Sanitation is a big factor in reducing ant infestations indoors. Most ants enter buildings in search of their favorite foods. Eliminating the food source for ants includes: removing all crumbs and spilled food and drinks from floors, tables, and counter tops; covering, sealing, and storing all prepared and unprepared food and drink items; properly storing all refuse; promptly washing all cooking and eating wares; and rinsing soda bottles before storing them.

To control ants indoors with chemicals, make spot treatments with approved and recommended insecticidal dusts or sprays. Approved ant baits can also be used. Before you select or use chemicals for controlling ants, refer to Appendix A (in a separate inclosure). Most importantly, always refer to your pesticide labels.

Apply a coarse spray of emulsions or solutions to areas where ants normally occur. You can apply these liquid formulations by using a small compressed air sprayer or a paint brush.

You can apply baits and dusts lightly near baseboards, in closets, under sinks and refrigerators, and other areas where ants normally occur, but only in areas that are inaccessible to children and pets.

Outdoor Ant Control. To control ants outdoors you should use the spot treatment application. Emulsions, suspensions, or dusts can be used for controlling ants outdoors as long as these formulations contain chemicals that are approved for this purpose and they are applied in accordance with label recommendations.

These formulations can be used for treating nests and approximately 6 inches around the nests and for treating various points along the ant trails. The mounds must be saturated; therefore, dusts must be watered into the nests.

Baits can be used for controlling fire ants in outdoor areas by applying these baits within a few inches of the mound entrance. Treating for fire ants is a special problem and must be accomplished with expertise.

Exercises (837):

Complete the following statements concerning the controls used in managing ants.

1. ____________ ____________ ____________ ____________ will cause ants to go to other areas for food.
2. Before storing soda bottles they should be ____________.
3. To control ants chemically indoors, ____________ treatments with insecticidal ____________ or ____________ should be accomplished. Approved ant ____________ can also be used.
4. Liquid formulations can be applied by using a small ____________ ____________ ____________ or a ____________ ____________.
5. Baits should be used only in areas which are inaccessible to ____________ and ____________.
6. For outdoor ant control, spot treatments with ____________, ____________, and/or ____________ can be used.
7. Ant mounds must be ____________, therefore, ____________ must be watered into the nests.
8. Treating for fire ants is a ____________ problem and must be accomplished with ____________.

2-6. Earwigs.

In your job, you will be called upon to rid various base facilities of earwigs from time to time. Although this task is generally not continuous you must still be able to identify these insects and control them. The term "earwig" is believed to have been derived from the belief that this insect would enter the ears of people while they slept and bore into the brain. In truth, earwigs are harmless to humans.

Earwigs are important household pests because they gather in lawns and invade building in great hordes. They can be serious morale and economic pests because the presence of these hordes often prevents people from enjoying outdoor activities and can depreciate property values. This insect is a pest of vegetation in a minor way, but it is also beneficial because it feeds upon other insects.

840. Correct false statements concerning the identification, habits, and habitats of earwigs.

Identification, Habits, and Habitats of Earwigs. Earwigs belong to the order Dermaptera and are short-winged insects that bear a pair of forceps at the posterior end of the abdomen. These forceps are relatively straight in the female but are bowed outward in the male. The adults are approximately 16 mm long, dark reddish brown, with a reddish head, and pale yellowish brown legs in color and have biting mouthparts.

These insects are omnivorous and will eat almost anything that they can chew. They are not known to fly readily or travel very far by crawling. Earwigs have a gradual metamorphosis. Their entire development from egg to adult is completed in approximately 5 months.

Earwigs, can be found outdoors in dark, moist crevices, such as between building foundations and soils, and under boards, stones, and welcome mats. They can be found indoors hiding in baseboard crevices, under furniture, and in basements.

Exercises (840):.

Identify the following statements as being correct or incorrect, and correct those that are false.

1. Earwigs belong to the order Acarina.

2. Earwigs are short-winged insects that bear a pair of forceps at the posterior end of the abdomen.

3. Adult earwigs are approximately 16 mm long, dark reddish brown, with a reddish head and pale yellowish brown legs.

4. Earwigs will develop from eggs to adults in about 2 months.

841. Discriminate between true and false statements concerning the control of earwigs.

Control of Earwigs. To prevent earwigs from entering buildings, you can apply a residual emulsion or suspension containing an approved insecticide outdoors. Apply the insecticide to the soil in a band 5 feet wide around the entire building. Treat the foundation wall from the ground to a height of 2 to 3 feet.

Spray or brush residuals of an approved insecticidal suspension on door and window sills, stoves, and other out-of-the-way places where you find these insects indoors. Use only the crack and crevice treatment in areas where foods are stored, prepared, and served.

Nonchemical controls for earwigs generally are not very effective; however, clearing vegetation away from building foundations and insuring that doors and windows fit snugly in their frames may prevent entry of these pests.

Exercises (841):

Decide whether the following statements are true or false.

___ 1. A good method of controlling earwigs is to paint or spray a residual emulsion on a band 5 feet wide around a building.

___ 2. You should treat cracks and crevices only in areas where food is prepared or stored.

___ 3. Nonchemical control of earwigs is normally effective.

2-7. Clovermites

This section covers, the important, identifying characteristics, habits, and habitats of the clovermite as well as the measures that you can use to control these arachnids.

Until about 1943, the clovermite was not of concern of humans, but since then it has become increasingly more important and is now considered to be a serious household and plant pest.

Clovermites enter buildings in great numbers in the springtime. Not only do they annoy people by swarming on them, but they may damage such items as walls, window shades, drapes, and furniture because they leave red spots when they are crushed.

842. Identify given statements concerning clovermites as being correct or incorrect and amend the false statements.

Identification, Habits, and Habitats of Clovermites. As you recall from Volume 4, clovermites are members of the class Arachnida and the order Acarina.

They are brownish or reddish and are about 0.75 mm long. They are different from other mites by being larger and having long front legs and featheryappearing plates on their bodies.

Clovermites can reproduce without a fertilized ovum (female parthenogenesis). The female deposits bright red eggs in such locations as under the basal bark of trees, in cracks and crevices of concrete foundations, and between walls. They feed on almost any type of herbacious plants and deciduous trees, as well as on some conifers, but they prefer herbacious plants.

Exercises (842):

Identify each of the following statements as being correct or incorrect, and correct those that are false.

___ 1. Clovermites are members of the class Arachnida.

___ 2. Clovermites are members of the order Acarina.

___ 3. Clovermites prefer to feed on herbaceous plants.

___ 4. The female usually deposits eggs in carpets and clothing.

___ 5. Clovermites are brownish or reddish in color and are approximately 0.75 mm long.

___ 6. Clovermites are capable of reproducing without a fertilized ovum.

___ 7. The eggs of the clovermite are white.

843. Prescribe the control methods that you should use for given clovermite control situations.

Control of Clovermites. Space treatments using aerosols provide immediate but temporary relief from these pests indoors. Therefore, after aerosol treatment, you should implement a more permanent type of control.

To provide long-lasting relief from these pests, treat interior and exterior surfaces of door and window frames and sills with approved residual insecticide emulsions or suspensions.

In addition to treating the exterior surfaces of door and window frames and sills, use a residual emulsion on the soil surrounding the building foundation (5 feet band) and the foundation walls (to a height of 3 feet). Approved insecticide emulsions or suspensions can be applied as residuals to lawns, shrubs, and trees that are near the building.

Exercises (843):

1. A building has been invaded by a large number of clovermites. What should you do immediately to provide relief for the occupants?

2. To provide for a long-lasting relief of these pests on both the interior and exterior of buildings, what should you do?

3. For an additional exterior treatment, what should you do?

2-8. Pillbugs and Sowbugs

Pillbugs and sowbugs are distributed throughout the world but are most abundant in areas of high humidity. These crustaceans are of concern to you as a pest manager only when they are present in great numbers.

Pillbugs and sowbugs are important to humans only as nuisance pests when they enter buildings. They are unsightly and they cause special concern to many people, especially those who are not familiar with them.

844. Associate given identifying characteristics and habits with the pillbug and sowbug.

Identifying Characteristics and Habits. Contrary to popular belief, pillbugs and sowbugs are not the same! Sowbugs can be distinguished from pillbugs because sowbugs cannot roll up into a ball as the pillbug can. This characteristic of the pillbug has prompted many people into referring to it as a "roly-poly." Another characteristic that is possessed by sowbugs that distinguishes them from pillbugs is the two prominent taillike appendages that are not present on pillbugs.

Both sowbugs and pillbugs are oval and somewhat flattened in shape. Both are grayish to black in color and are approximately 12.5 mm long.

Pillbugs and sowbugs belong to the class Crustacea, order Isopoda, thus they have a need for high humidity. These crustaceans prefer very moist areas and can be found outdoors under almost any object. They may also be found under piles of decaying grass cuttings and vegetable matter and in cracks that are between building foundations and soils. Pillbugs and sowbugs can be found primarily in damp basements and ground level floorings of buildings.

Sowbugs and pillbugs normally feed at night upon decaying vegetable matter, roots of small plants, and often on mushrooms. Females give birth to living young and the young develop into adults through a series of molts. Because these crustaceans are generally inactive during the winter months, they are only pests during the warmer seasons.

Exercise (844):

1. Identify the statements below as they apply to pillbugs or sowbugs; place a P or an S in the blank spaces provided to indicate pillbug or sowbug. Some statements may apply to both.

___ a. Not capable of rolling up into a ball.
___ b. Belong(s) to the class Crustacea.
___ c. Feed at night on decaying vegetation, roots of small plants, and sometimes mushrooms.
___ d. Sometimes referred to as a "roly poly."
___ e. Two prominent taillike appendages.
___ f. Oval and somewhat flattened.
___ g. Grayish to black in color.
___ h. About 12.5 millimeters in length.
___ i. Give birth to living young.

845. Detail the measures that you can use to manage pillbugs and sowbugs.

Physical Measures. Since these crustaceans congregate in large numbers under and between objects, you can pour hot water over them to destroy the ones in a certain group. You can also distribute hot water around the edges of building foundations to kill any pillbugs and sowbugs that have congregated in these areas.

Site sanitation includes such measures as removing grass and leaf piles, picking up objects that lay upon the ground, and keeping the area free of garbage.

To control these pests in basements and ground floor areas without chemicals, keep these areas dry and well ventilated. Make sure that doors and windows fit snugly in their frames and that objects are stored off the floor and away from walls. Raise windows in dry weather for ventilation, but keep windows and doors closed in damp weather.

Chemical Measures. You can control these crustaceans chemically by applying an approved pesticide emulsion or suspension to entire lawn and turf areas or as a band treatment around a building foundation. Of course, you must apply these formulations in accordance with the information provided on the pesticide label.

***Exercises* (845):**

Complete the following statements concerning the control measures used for managing pillbugs and sowbugs.

1. Pillbugs and sowbugs can be controlled by using ____________ and ____________ ____________ measures.
2. They can be killed by pouring ____________ on them.
3. Site sanitation includes such measures as removing ____________ and ____________ ____________, picking up objects laying on the ____________, and keeping the area free of ____________.
4. Control of these pests in basements and ground floor areas without chemicals can be accomplished by keeping these areas ____________ and well ____________.
5. Chemical control of these crustaceans may be obtained by applying an approved ____________ ____________ or ____________ to entire ____________ and ____________ areas or as a ____________ treatment around the building foundation.

Answers for Exercises

CHAPTER 1

Reference:

800 - 1. Neurotoxin.
2. Vesicating toxin.
3. Hemolytic toxin.

801 - 1. b.
2. e.
3. a.
4. d.
5. g.
6. c.
7. f.
8. a.

802 - 1. C.
2. C.
3. I. They produce honey and pollenate crop-bearing plants.
4. I. It does not harden readily and remains pliable for years.
5. C.
6. I. They cause serious damage to structures.
7. I. Deaths have been reported from bee stings.
8. C.

803 - 1. All bees.
2. Honeybees.
3. Bumblebees.
4. Bumblebees.
5. Bumblebees.
6. Honeybees.
7. Bumblebees.
8. Bumblebees.

804 - 1. If you can handle bees, gently rake them onto a white cotton cloth. When you have collected all the bees, take them to an open field and release them. If you or someone in your shop cannot handle bees, contact a beekeeper to take care of them for you. Beekeepers are usually glad to get the bees and you avoid killing the bees with chemicals.
2. Application of insecticide dust, spray, or aerosol will control these bees; however, several applications may be required. Dust is probably the best insecticide to use in this situation.

805 - 1. Stinging.
2. Individual.
3. Insects, crops.
4. Vegetation.

806 - 1. C.
2. I. It is used for making holes for depositing eggs and for stinging.
3. I. Some wasps are solitary insects and cause very little trouble to humans.
4. C.
5. C.

807 - 1. Avoided.
2. Letting it out; aerosol bomb.
3. Dust; solution formulations; night.
4. Wear protective clothing.
5. Removed; crushed; egg; larvae; pupae.
6. Destroyed; reuse.
7. Carbaryl; propoxur; resmethrin.
8. I. O.
9. Dust.
10. Saturate nest with spray.

808 - 1. c. The hornet sting is worse than all other bees including the yellow jacket.
d. They are helpful in a small way in that they do parasitize certain other insects and arachnids.

809 - 1. Medical attention.
2. Wasp; hornet; removed.
3. Tweezers.
4. Paste; bicarbonate; soda.
5. Speeds; venom; inflammation.

810 - 1. C.
2. I. Very few species in the United States are poisonous.
3. C.
4. C.
5. I. They appear in many parts of the world.
6. I. The black widow is more important.
7. C.
8. I. Both sexes are poisonous.
9. I. A full bite affects body functions as well as creating a very serious local wound.
10. C.

811 - 1. Temperate; tropical.
2. Paralyze.
3. Humans; most.
4. Mouthparts; skin.
5. Instars.

812 - 1. a. 3.
b. 3, 4, 5.
c. 1.
d. 2.
e. 3.
f. 1.
g. 4.
h. 2.
i. 1, 5.
2. a. 200.
b. 2; 4.
c. summer; spring.

d. Privy seats; lumber; trash; paint cans; buckets.
e. Insects; distrubed.
f. Fiddle.
g. One; five.
h. Houses; buildings; boiler houses; schools; churches; libraries; stores.
i. Light; seen.
j. Out of doors.

813 - 1. Cleaning up; breeding areas; destroying; killing; egg.
2. Insecticidal.
3. Drop; webs; crushed.
4. Carbomates; organophosphates.
5. Contact; poisonous.
6. Propoxur; chlorpyrifos; diazinon.
7. 0.25 to 0.5.
8. S.

814 - 1. Venoms.
2. Because first-aid treatment is ineffective.
3. Medical.

815 - 1. 1, 2, 4, 5 are True.
2. They seldom grow larger than 7.5 cm.

816 - 1. Four; one.
2. Two; unsegmented; segmented.
3. Tail; stinger.
4. Straw-yellow; black; body.
5. Nocturnal; day.
6. Water.
7. House; attics; walls.

817 - 1. Insects.
2. 2; 3.
3. Hiding.
4. Burlap; evening.
5. Diazinon; propoxur.

818 - 1. Ligature (a tight tourniquet); sting; body.
2. Ice.
3. 3; 5.
4. Antivenins.
5. Professional.

819 - 1. 1. b.
2. h.
3. c.
4. b.
5. a.
6. g.
7. h.
8. a.
9. c.
10. b.
11. e.
12. d.
13. g.
14. e.
15. b.
16. d.

820 - 1. 1. Diazinon.
2. Propoxur.
3. Residuals; doorways; window frames; lighting.
4. Diazinon; carbaryl; malathion.

821 - 1. True.
2. True.
3. False. Low.
4. True.
5. False. Can.
6. False. Do *not*.
7. False. Mankind fear snakes because they lack knowledge of snakes and believe fallacies that have been passed down through generations.

822 - 1. 1. c.
2. a.
3. b.
4. a.
5. c.
6. c.
7. a.
8. a.
9. b.
10. b.
2. Flat.
3. Large.
4. Heads.
5. Deserts.
6. Largest; most.

823 - 1. False. Neurotoxic.
2. True.
3. False. Both from family Elapidae.
4. True.
5. False. The cobra has a "hood."
6. True.
7. False. Arizona and New Mexico.
8. True.
9. False. They are secretive.
10. True.

824 - 1. a. Pain.
b. Nausea.
c. Respiratory difficulty (possibly a sign also).
d. Visual difficulty.
2. a. Presence of fang puncture wounds.
b. Drooping of eyelids.
c. Unsteady gait.
d. Slurring of speech.
e. Swelling at puncture point (possibly).
f. Vomiting.
g. Excessive sweating.

825 - 1. Correct.
2. Incorrect. Only a doctor or other suitably trained medical personnel may administer antivenin.
3. Incorrect. Change "2" to "1."
4. Correct.
5. Correct.
6. Correct.

826 - 1. Rodent.
2. Avoid.
3. Chlorinated; dust.
4. Hip boots; flashlight.
5. Burlap sacks.

CHAPTER 2

827 - 1. Homes; hotels; restaurants; bakeries.
2. Cracks; crevices.
3. Bits; food; lives; travels.
4. Predaceous.
5. Diarrhea; dysentery; typhoid; food poisoning; food.
6. Mealworms; fleas.
7. 55.
8. At night, warm; damp; secluded.
9. Oothecae.
10. Nymphs; adults.

828 - 1. a. 4.
b. 1.
c. 5.

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d. 3.
e. 2.

829 - 1. Good sanitation.
2. Chemical.
3. Food scraps; residue; greasy films.
4. Vending.
5. Closed.
6. Spot; coarse; dust.
7. Asphalt; vinyl.
8. Liquid; penetration.
9. Visible; unsightly.
10. Residual; recesses.
11. Resistance.

830 - 1. C.
2. I. They also attack starched clothing, linen, and rayon.
3. C.
4. C.
5. I. Both are wingless.
6. I. Firebrats prefer hot dry places.

831 - 1. Cockroach.
2. Furniture; carpets; cloth.
3. Coarse; paint; baseboards; cabinets; refrigerators; sinks; stoves.

832 - 1. 5 mm long 3 mm wide, and reddish brown.
2. Greatly enlarged and red.
3. Both sexes; *Cimex lectularius, Cimex hemipterus.*
4. Nervous and digestive disorders.

833 - 1. Buggy odor; blood; fecal.
2. Night.
3. Metamorphosis.
4. Meal; blood.
5. 18; 56; temperature.
6. 6; 12.
7. Year; food; freezing.

834 - 1. I.
2. C.
3. C.
4. I.
5. I.
6. C.
7. C.

835 - 1. a.
2. b.
3. c.
4. a.
5. c.
6. b.

836 - 1. Residuals.
2. Floors; walls; ceiling; fireplaces; dark crevices; in basements; baseboards.
3. Cracks; crevices.
4. Spraying; brushing.
5. Baits.
6. Congregate.
7. Residuals; 5; soil; foundation; 2; 3.

837 - 1. Sweets; meats; grease.
2. Enteric; feces; garbage.
3. Sting.
4. Sensitive.
5. Venomous; southwestern.
6. Scavengers; predators.
7. Larger.
8. Chewing; mandibles; biting; piercing; cutting; gnawing.
9. 0.06; 3.8.
10. Years; man.
11. Feed; tunnels, care.
12. Broad; new colonies.

838 - 1. f.
2. a.
3. d.
4. c.
5. b.
6. e.

839 - 1. Eliminating the food supply.
2. Rinsed.
3. Spot; dusts; sprays; baits.
4. Compressed air sprayer; paint brush.
5. Children; pets.
6. Emulsions; suspensions; dusts.
7. Saturated; dusts.
8. Special, expertise.

840 - 1. Incorrect, Dermaptera.
2. Correct.
3. Correct.
4. Incorrect. 5 months.

841 - 1. True.
2. True.
3. False.

842 - 1. Correct.
2. Correct.
3. Correct.
4. Incorrect. Under the basal bark of tree, in cracks and crevices, and between walls.
5. Correct.
6. Correct.
7. Incorrect. Red.

843 - 1. Treat the space with aerosols.
2. Treat the interior and exterior surfaces of doors, window frames, and sills with an approved insecticide emulsion or suspensions.
3. Treat the soil surrounding the building foundation (5-foot band) and the foundation walls (3-foot height) with an emulsion. Apply approved emulsions or suspensions to lawns, shrubs, and trees.

844 - 1. a. S.
b. P, S.
c. P, S.
d. P.
e. S.
f. P, S.
g. P, S.
h. P, S.
i. P, S.

845 - 1. Chemical; nonchemical (physical).
2. Hot water.
3. Grass; leaf piles; ground; garbage.
4. Dry; ventilated.
5. Pesticide emulsion; suspension; lawns; turf; band.

STOP - **1. MATCH ANSWER SHEET TO THIS EXERCISE NUMBER.**
2. USE NUMBER 2 PENCIL ONLY.

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EXTENSION COURSE INSTITUTE
VOLUME REVIEW EXERCISE
56650 05 21
HOUSEHOLD PESTS, VENOMOUS ARTHROPODS, AND REPTILES

Carefully read the following:

DO's:

1. Check the "course," "volume," and "form" numbers from the answer sheet address tab against the "VRE answer sheet identification number" in the righthand column of the shipping list. If numbers do not match, take action to return the answer sheet and the shipping list to ECI immediately with a note of explanation.
2. Note that item numbers on answer sheet are sequential in each column.
3. Use a medium sharp #2 black lead pencil for marking answer sheet.
4. Write the correct answer in the margin at the left of the item. (When you review for the course examination, you can cover your answers with a strip of paper and then check your review answers against your original choices.) After you are sure of your answers, transfer them to the answer sheet. If you have to change an answer on the answer sheet, be sure that the erasure is complete. Use a clean eraser. But try to avoid any erasure on on the answer sheet if at all possible.
5. Take action to return entire answer sheet to ECI.
6. Keep Volume Review Exercise booklet for review and reference.
7. If mandatorily enrolled student, process questions or comments through your unit trainer or OJT supervisor. If voluntarily enrolled student, send questions or comments to ECI on ECI Form 17.

DON'Ts:

1. Don't use answer sheets other than one furnished specifically for each review exercise.
2. Don't mark on the answer sheet except to fill in marking blocks. Double marks or excessive markings which overflow marking blocks will register as errors.
3. Don't fold, spindle, staple, tape, or mutilate the answer sheet.
4. Don't use ink or any marking other than a #2 black lead pencil.

NOTE: **NUMBERED LEARNING OBJECTIVE REFERENCES ARE USED ON THE VOLUME REVIEW EXERCISE.** In parenthesis after each item number on the VRE is the Learning Objective Number where the answer to that item can be located. When answering the items on the VRE, refer to the Learning Objectives indicated by these Numbers. The VRE results will be sent to you on a postcard which will list the actual VRE items you missed. Go to the VRE booklet and locate the Learning Objective Numbers for the items missed. Go to the text and carefully review the areas covered by these references. Review the entire VRE again before you take the closed-book Course Examination.

MULTIPLE CHOICE

1. (800) Most arthropods and reptiles in the United States produce

   a. a neurotoxin.
   b. an urticating venom.
   c. a hemmorhagic toxin.
   d. a hemolytic venom.

2. (801) The method of envenomization and the type of venom produced by wasps are

   a. stings, hemolytic.
   b. stings, neurotoxin.
   c. bites, neurotoxin.
   d. bites, hemolytic.

3. (801) The method of envenomization and the type of venom produced by bees are

   a. stings, hemolytic.
   b. stings, neurotoxin.
   c. bites, neurotoxin.
   d. bites, hemolytic.

4. (802) Which of the following bees is the most beneficial to humans in respect to food production?

   a. Carpenter bee.
   b. Honeybee.
   c. Bumblebee.
   d. King bee.

5. (803) Which of the following descriptions would identify a bumblebee?

   a. Nest in the ground, hairy bodies, no pollen basket.
   b. Nest in the ground, hairy faces, pollen basket.
   c. Nest above ground, hairy faces, pollen basket.
   d. Nest above ground, hairy bodies, no pollen basket.

6. (804) Insecticidal dust to control bees should be applied weekly for

   a. 1 to 2 weeks.
   b. 2 to 3 weeks.
   c. 3 to 4 weeks.
   d. 4 to 5 weeks.

7. (805) Wasps are very beneficial to humans in food production because they

   a. produce honey.
   b. produce beeswax.
   c. are parasitizers.
   d. are good pollinators.

8. (806) Which of the following statements describes the wasp?

   a. Two pairs of membranous wings, forewings larger than hindwings.
   b. One pair of hairy wings, forewings smaller than hindwings.
   c. Two pairs of hairy wings, forewings larger than hindwings.
   d. Two pairs of hairy wings, hindwings larger than forewings.

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9. (807) To control wasps that have established nests, treat the nest

a. at night.
b. at midday.
c. with approved insecticidal dust.
d. as stated in options a and c above.

10. (808) Which of the following statements reflects the habit of the hornet?

a. Construct paperlike nests with exposed cells.
b. Construct completely inclosed paperlike nests.
c. Construct mud nests resembling vases.
d. May burrow into the ground to nest.

11. (809) When you have an embedded sting in your arm, you should

a. carefully remove it with tweezers.
b. carefully remove it with a sharp knife.
c. seek immediate medical aid.
d. apply a suction cup to remove the venom.

12. (810) The most important poisonous spider within the United States is the

a. brown recluse.
b. brown widow.
c. black widow.
d. red widow.

13. (811) Spiders belonging to the class arachnids are identified as having

a. segmented abdomen, eight legs, no wings, and no antennae.
b. segmented abdomen, six legs, no wings, and two antennae.
c. unsegmented abdomen, six legs, no wings, and two antennae.
d. unsegmented abdomen, eight legs, no wings, and no antennae.

14. (812) Which of the following statements identify a brown recluse spider?

a. Dark fiddle-shaped band on the anterior portion of the carapace.
b. The abdomen is dark brown splotched with yellow.
c. Usually brown or grey with red hourglass markings.
d. Not shiny black, but smokey black.

15. (813) Which of the following residual insecticides can be applied in a dust form to control spiders?

a. Pyrethrins.
b. Baygon.
c. Dursban.
d. Diazinon.

16. (814) To treat a victim bitten by a widow or brown spider,

a. swab the biten area with iodine.
b. use first-aid treatment immediately.
c. apply a sodium bicarbonate paste and cover with a hot pack.
d. seek trained medical personnel to administer treatment.

17. (815) The scorpions of medical importance found mainly in southern Arizona are members of genus

a. Tityus.
b. Buthus.
c. Perabuthus.
d. Centruroides.

18. (816) The scorpion has four pairs of legs and a body with two divisions,

a. unsegmented cephalothorax and unsegmented abdomen.
b. unsegmented cephalothorax and segmented abdomen.
c. segmented cephalothorax and segmented abdomen.
d. segmented cephalothroax and unsegmented abdomen.

19. (817) The two residual insecticides used to control scorpions are

a. propoxur and chlorpyrifos.
b. diazinon and dichlosovos.
c. malathion and pyrethrin.
d. diazinon and propoxur.

20. (818) In rending first-aid treatment to a victim stung by a posionous scorpion, you would

a. apply a tourniquet as near to the sting as possible.
b. apply hot compresses on the sting area to draw out the venon.
c. immediately swab the sting area with alcohol.
d. do all of the above.

21. (819) A cone-shaped head with a three jointed proboscis carried in a folded position close to the body--these are characteristics of which of the following insects?

a. Brown-tail moth.
b. IO moth.
c. White-marked tussock.
d. Conenose.

22. (820) You can control centipedes and millipedes around buildings by using the residual insecticide

a. malathion.
b. aluminum phosphide.
c. propoxur.
d. pyrethin.

23. (821) Which one of the following statements is true concerning snakes?

    a. A horsehair rope does not stop a snake.
    b. Snakes can't bite underwater.
    c. Snakes take milk from a cow.
    d. A hoop snake chases people by holding its tail in its mouth and rolling over and over.

24. (822) The snake which feeds largely on rabbits and quail is the

a. moccasin.	c. horned rattlesnake.
b. copperhead.	d. eastern diamondback.

25. (822) Which of the following snakes will seek cover quickly when disturbed except when cornered?

a. Moccasin.	c. Horned rattlesnake.
b. Copperhead.	d. Eastern diamondback.

26. (823) The coral snake belongs to the family

a. Bostrichidae.	c. Lycidae.
b. Anobiidae.	d. Elapidae.

27. (824) Which of the following symptoms describes the envenomization by pit vipers?

    a. Excessive salivation and sweating.
    b. Slurring of speech and tingling sensation.
    c. Prompt and progressive swelling.
    d. Drooping of eyelids and unsteady gait.

28. (824) Which of the following symptoms describes the envenomization by coral snakes?

    a. Bruiselike discoloration.
    b. Shock, vomiting, and nausea.
    c. Local decay of tissue.
    d. Excessive salivation and sweating.

29. (825) Incision and suction treatment for a snake bite should be started within

    a. 10 minutes, but not after 1 hour.
    b. 10 minutes, but not after 2 hours.
    c. 20 minutes, but not after 1 hour.
    d. 20 minutes, but not after 2 hours.

30. (826) For the control of snakes, the method which has been proved somewhat effective is

    a. organophosphate pesticidal emulsions.
    b. chlorinated hydrocarbon pesticidal dust.
    c. organophosphate pesticidal dusts.
    d. chlorinated hydrocarbon pesticidal emulsions.

31. (827) How many species of cockroaches are common pests indoors in the United States?

a. 5.
b. 20.
c. 35.
d. 55.

32. (828) Which is the largest of the major cockroaches?

a. Brown-banded.
b. Australian.
c. Oriental.
d. American.

33. (828) What cockroach resembles the German cockroach but is slightly smaller?

a. Australian.
b. American.
c. Brown-banded.
d. Oriental.

34. (828) How long does the female oriental cockroach carry the dark reddish-brown egg capsule before depositing it?

a. 2 weeks.
b. 12 hours.
c. 30 hours.
d. 1 month.

35. (828) Which are the two filthiest of the major species of cockroaches?

a. Brown-banded and German.
b. American and brown-banded.
c. American and Oriental.
d. Oriental and German.

36. (828) Which of the following cockroaches is the less serious pest of the major species?

a. American.
b. Australian.
c. German.
d. Oriental.

37. (829) To achieve and maintain effective control of the cockroach, it is imperative that you have

a. chemical control.
b. good sanitation.
c. aerosol treatment.
d. food supply for cockroaches.

38. (829) What insecticides have been routinely used for the control of the German cockroach?

a. Chlordane.
b. Nicotine sulfate.
c. Pyrethrum.
d. Organophosphorus.

39. (830) Where will silverfish harbor?

a. Duct work for a heating system.
b. Food storage and moist places.
c. Behind stoves or around fireplaces.
d. Under hot, dry conditions.

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40. (830) What is the shape of silverfish and firebrats?

    a. Carrot.
    b. Beet.
    c. Diamond.
    d. Hexagon.

41. (831) What type of chemical treatment is normally used to control silverfish?

    a. Application of residual insecticide emulsions.
    b. Misting.
    c. Fogging.
    d. Aerosoling.

42. (832) To what family does the bedbug belong?

    a. Supella supellectilium.
    b. Blatella germanica.
    c. Cimicidae.
    d. Lespisma.

43. (832) What specie of bedbugs is predominate in the temperate region?

    a. Supella supellectilium.
    b. Blatella germanica.
    c. Cimex hemipterus.
    d. Cimex lectularius.

44. (833) Depending on the temperature, how long does it take for complete development of a bedbug from egg to adult?

    a. 10 to 15 days.
    b. 8 to 12 weeks.
    c. 18 to 56 days.
    d. 1 to 2 weeks.

45. (834) How long will one application of an approved insecticide emulsion control bedbugs?

    a. 30 days.
    b. 6 months.
    c. 1 year.
    d. more than 1 year.

46. (835) To what order does the cricket belong?

    a. Orthoptera.
    b. Hemiptera.
    c. Lespisma.
    d. Supella.

47. (835) What cricket enters the home chiefly in cold weather?

    a. House.
    b. Cave.
    c. Camel.
    d. Jerusalem.

48. (835) Which of the following crickets are believed to have venomous bites?

    a. House.
    b. Cave.
    c. Camel.
    d. Jerusalem.

49. (836) Control treatment for crickets in food facilities must be restricted to

a. line area only.
b. cracks and crevices.
c. flat surfaces.
d. the entire room.

50. (836) How can you prevent crickets from entering buildings?

a. Residuals.
b. Misting.
c. Fogging.
d. Aerosoling.

51. (837) How are ant colonies established?

a. The male and the female dig a nest, discard their wings, and both produce eggs for a new brood.
b. The male digs a nest so that the female can produce her eggs.
c. The female lays her eggs, and the male digs a nest and covers the eggs.
d. The newly mated female discards her wings, digs a nest, and produces eggs for a new brood.

52. (837) All ants will

a. sting.
b. bite.
c. eat sweets.
d. eat meats.

53. (838) Which ant is the most difficult to control in the home?

a. Thief.
b. Pharaoh.
c. Little black ant.
d. Argentine.

54. (838) Which ant is one of the smallest?

a. Thief.
b. Pharaoh.
c. Little black ant.
d. Argentine.

55. (838) What is the natural food of the little black ant?

a. Greases from cooked foods.
b. Sweets from cooked foods.
c. Sweets and greases.
d. Honeydew that is derived from aphids.

56. (839) When applying pesticide to an ant nest outside, you apply it to the nest and in a

a. 3-inch band around the nest.
b. 6-inch band around the nest.
c. 12-inch band around the nest.
d. 18-inch band around the nest.

57. (840) To what order do earwigs belong?

a. Orthoptera.
b. Cimex hemipterus.
c. Dermaptera.
d. Domestica.

58. (840) What type mouthparts does the earwig have?

    a. Biting.
    b. Sucking.
    c. Chewing.
    d. Vacuum.

59. (841) When spraying for earwigs, where would you spray outdoors?

    a. In the water area only.
    b. In the soil in a 5-foot band around the structures and on the foundation wall to a height of 2-3 feet.
    c. Only on the foundation wall to a height of 2-3 feet.
    d. Only in a 5-foot band on the soil around the structure.

60. (842) How can the clovermites be distinguished from other mites?

    a. Clovermites are larger than other mites and have long front legs and feathery-appearing plates on their bodies.
    b. Clovermites are smaller than other mites and have wide spread legs.
    c. Clovermites are green in color and are a lot larger on the plates of their bodies than other mites.
    d. Clovermites can fly, other mites cannot.

61. (843) What is a temporary control for clovermites?

    a. Sprinkle dust on the floors.
    b. Employ space treatments, using aerosols.
    c. Use an approved insecticide emulsion or suspensions.
    d. Use the spray outside and inside.

62. (844) How can sowbugs be distinguished from pillbugs?

    a. Sowbugs roll up into a ball.
    b. Sowbugs are longer and have a flat head.
    c. Sowbugs cannot roll up into a ball.
    d. The sowbug is known as the "roly-poly."

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CDC 56650

ENTOMOLOGY SPECIALIST

(AFSC 56650)

Volume 6

Collection, Identification, and Control
of Important Economic Pests

Extension Course Institute

Air University

491

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THIS PUBLICATION HAS BEEN REVIEWED AND APPROVED BY COMPETENT PERSONNEL OF THE PREPARING COMMAND IN ACCORDANCE WITH CURRENT DIRECTIVES ON DOCTRINE, POLICY, ESSENTIALITY, PROPRIETY, AND QUALITY.

Preface

THIS VOLUME OF CDC 56650, *Entomology Specialist,* provides you with knowledge concerning the more important economic pests, which include stored product pests, structural pests, and ornamental and turf pests. In order for you to become a certified pest controller, you must be very knowledgeable in these subjects as well as those previously discussed.

Please note that in this volume, we are using the singular pronouns *he, his,* and *him* in the generic sense, not the masculine sense. The word to which these pronouns refer is person.

Please note that in this volume, we are using the singular pronouns *he, his,* and *him* in the generic sense, not the masculine sense. The word to which these pronouns refer is person.

If you have questions on the accuracy or currency of the subject matter of this text, or recommendations for its improvement, send them to Tech Tng Cen/TTGOX, Sheppard AFB TX 76311. NOTE: Do not use the suggestion program to submit corrections for typographical or other errors.

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This volume is valued at 3 hours (11 points).

Material in this volume is technically accurate, adequate, and current as of September 1977.

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CHAPTER 1

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NOTE: In this volume, the subject matter is developed by a series of Learning Objectives. Each of these carries a 3-digit alphanumeric identifier and is in boldface type. Each sets a learning goal for you. The text that follows the objective gives you the information you need to reach that goal. The exercises following the information give you a check on your achievement. When you complete them, see if your answers match those in the back of this volume. If your response to an exercise is incorrect, review the objective and its text.

Stored Product Pests

THERE ARE MANY insects that are important as stored product pests to the civilian community and to the Air Force. The majority of these insects are in either the order Coleoptera, the beetles, or the order Lepidoptera, the moths. These pests are divided into two groups according to the type of product they generally infest. These groups include those pests that infest fabrics and those that infest foods.

Insects steal our food, infest our dwellings, and damage our property. Through the centuries, an increasing number of insects have been adapted to indoor life, preferring buildings because of the moderate temperature, plentiful food and water, and abundant harborage.

Economically, the second most costly pests at military installations are the stored product pests. These pests destroy a variety of products composed of, or derived from, materials of plant or animal origin. Damage may occur at the point of origin, in transit, or in storage.

This chapter covers the more important pests within each group by providing you with descriptions and other important aspects of each of these pests. In addition, the survey and control procedures are also provided.

Appendix B is in the supplement of Volumes 4, 5, 6, and 7 to help you make field identification of common stored product pests.

1-1. Fabric Pests

Fabric pests are important to us in that they at times infest and damage Air Force facility furnishings and our own furnishings and clothing. These pests can be very costly, especially when infestations become severe. Problems with these pests have been reduced immensely with the manufacture of many home furnishings and clothing from synthetic materials. However, synthetic materials cannot be considered entirely safe from fabric pests because many are still susceptible to attack.

This section covers the important fabric pests by providing you with information pertaining to their description, importance, development and control.

A01. Associate given fabric pests with statements concerning their identification, importance, and development.

There are two moths and four beetles that are included in this group because of their attacks on products containing hair, wool, and hides.

Webbing Clothes Moth. The webbing clothes moth attacks wool, hair, and fur. It is a most destructive insect, damaging woolen clothing and furnishings. The webbing clothes moth is about 13 mm long and is covered with shiny golden scales. It has a tuft of reddish-golden hair on its head and has black eyes. The antennae are darker than the rest of the body. This particular moth avoids strong light. The eggs are laid on food and are secured with gelatinous material. They are usually placed deep in the fibers. The larvae will often spin feeding funnels. They may feed some distance from this tube or abandon it altogether and build another one. When ready to pupate, the larvae spin silken pupal cases.

Casemaking Clothes Moth. The casemaking clothes moth feeds on wool, hair, bristles, felts, feathers, hides, tobacco, drugs, spices, and nut meats. It has a wingspread of 13 to 15.5 mm and has a more brownish hue than the webbing clothes moth. There are three dark spots on each wing, but they are easily rubbed off. The life cycle is similar to that of the webbing clothes moth except for the larval stage. The larva spins a silken case and carries it with it as it moves about. The larva will die if removed from this case. When it is ready to pupate, it seals up both ends of the case.

Black Carpet Beetle. This beetle is the most destructive carpet beetle in the United States. It is distributed throughout the country. The adult is a small, black, or dark brown beetle not over 4.6 mm long, sometimes flecked with white or reddish scales. The adults feed on the pollen of flowers. The life cycle varies from 1 to 2 years and only the larval stage attacks stored products. The larva is long (about 9.3 mm) and narrow with golden setae on the body and a tuft of long setae at the posterior end. When disturbed, it curls up and "plays possum." Larvae feed upon seeds, grain, woolens, silks, felts, skins, feathers, milk powder, and many other materials. They are often abundant under undisturbed portions of carpets (such as under sofas and large chairs) and in dark corners. The damage may not be noticed until a heavy infestation has developed. Its larvae may cause canthariasis.

Common Carpet Beetle. The common carpet beetle is a special pest of carpets, but it also attacks woolen and other animal products, such as feathers, leather, furs, hairbrushes, silks, and museum specimens. The adult is oval in shape, about 3 mm long, basically black in color with minute whitish scales and a longitudinal band of orange red scales around the eyes. The adults feed on nectar and pollen. The eggs may be simply dropped upon the surface of fabrics or they may be thrust deeply into the fabric so that only one end remains visible. The eggs are small, whitish in color, and have projections at one end. These projections help them attach to fabrics. The larva, which is the destructive stage, is reddish brown with numerous black and brown hairs and is approximately 3 mm long.

Furniture Carpet Beetle. The adult furniture carpet beetle is very colorful. It is basically black in color; however, it is covered with yellow and white scales and presents a mottled yellow-white and black appearance on its dorsal surface. This beetle is oval in shape and is from 2 to 3.5 mm long.

The adult female usually deposits her small white eggs in the pile of mohair, in the nap of clothes, on the surface of clothes, or in cracks and crevices of flooring.

The larva is very similar in appearance to the common carpet beetle larva, but differs in that the furniture carpet beetle larva has peculiar spearheaded hairs protruding from the posterior tufts.

Spider Beetle. There are many species of spider beetles; therefore, this discussion is based on their general characteristics.

The adults are very small (usually from 2 to 4 mm), oval or cylindrical beetles that appear as giant mites or very small spiders. Most of these beetles are reddish brown.

The larva feeds on wool, hair, and feathers and will also feed upon fabrics and cereals. These pests are capable of surviving in very cold temperatures for extended periods of time. This ability probably accounts for their presence in cereal products in Canada and the Northern United States.

Exercises (A01):

Match the description in column A with the fabric pest in column B.

Column A

___ 1. Larvae are long and narrow with golden setae on the body
___ 2. Blackeyed adult is covered with shiny golden scales with reddish-golden hair its head.
___ 3. Pest capable of surviving in a very cold temperature.
___ 4. Adult is black in color with minute whitish scales and longitudinal band of orange-red scales around the eyes.
___ 5. Adult is basically black; however, it is covered with yellow and white scales.
___ 6. Larvae will die if removed from the case.

Column B

a. Webbing clothes moth.
b. Casemaking clothes moth.
c. Black carpet beetle.
d. Common carpet beetle.
e. Furniture carpet beetle.
f. Spider beetle.

A02. Complete given statements pertaining to the damages incurred by fabric pests and to the surveys for these fabric pests.

Damage Recognition and Survey of Fabric Pests. In most cases the presence of fabric pests goes undetected until someone sees that furnishings or clothing have been damaged. When these damages are discovered, you may be called upon to determine whether or not the damages were caused by fabric pests. Since damages incurred by these pests may often resemble damages caused by such mechanical means as scissors, snags, punctures, cigarette burns, rodents, or termites, you must be capable of recognizing the differences. The descriptions of damages and the probable cause of the damages provided in table 1-1, should help you.

If you decide that fabric pests were actually responsible for the damages incurred to the fabrics, you must conduct a survey to determine whether there is an existing infestation. Keep in mind that the damage may be old and may have occurred elsewhere.

In conducting fabric pest surveys, you should inspect all clothing and clothing storage areas thoroughly for further damages and the presence of adults, pupa skins, and/or larva. In addition to inspecting clothing and clothing storage areas, you should inspect all other fabric furnishings contained in the facility. While conducting these inspections, pay close attention to all hidden areas, such as the seams and pockets of clothing, corners of storage areas, and beneath and behind the cushions of sofas and chairs.

Exercises (A02):

1. In most cases the presence of fabric pests goes ________________ until ________________.
2. Damages incurred by fabric pests may often resemble damages caused by mechanical means such as __________, snags, and punctures, or ____________________, ____________________, and __________.

TABLE 1-1

DAMAGE ASSEMSSMENT FOR FABRIC PESTS

Probable Cause	Damage Description
1. Webbing Clothes Moth	Usually fixed silk tubes sometimes bearing frass, this frass often showing the color of the cloth. Nap of wool eaten away in spots if lightly damaged; holes completely through fabric if infestation is extensive. Larvae may be present in the tubes. If fur, hairs are cut at base causing loose fur and exposing the hide with some webbing present. Fecal pellets are bun-shaped.
2. Casemaking Clothes Moth	Cigar-shaped cases 1/16" to 3/8" (size depending on larval age) usually attached to the fabric at one end. Cases white or bearing slight colors of the infested fabric. Cases appear to move about if larvae are inside and are stationary if they contain pupae or if empty. If cases are absent, damage is recognized as surface feeding in irregular furrows or when damage is severe, by holes through the fabric. Webbing essentially absent.
3. Mechanical Damage	Fabric actually cut; threads pulled, broken, torn, or looped; and exposed ends frayed. No loss of threads unless section of fabric torn out. Damage to neighboring area not expected. In rugs, loops pulled out.
4. Rodents	Damage is very similar to mechanical damage but the damaged area may be soiled and hairs may be present.
5. Burns	Irregular or round holes in wool that may or may not penetrate fabric. Tips of exposed threads usually curled and charred. In fur curling of damaged hairs; leather scorched.
6. Black Carpet Beetle	Fabric damaged with no traces of silk-like threads. Much surface damage with various penetrating holes. If infestation light, damage may be limited to scattered holes with surrounding surface damage. A few or many cast larval skins may be present. Frass in the form of minute irregular pellets often the color of the fabric. In fur, hairs cut at base with no injury to hide; hair drops out readily and hide may be bare in severe infestations. Cast skins; no webbing.
7. Furniture and Common Carpet Beetles	Fabric damaged with no traces of silk-like threads. Much surface damage with various penetrating holes. If infestation light, damage may be limited to scattered holes with surrounding surface damage. A few or many cast larval skins may be present. Frass in the form of minute irregular pellets often the color of the fabric. In fur and brushes, principal damage to tips of hair leaving numerous uneven areas.
8. Hide Beetles	Hide rather badly damaged on exposed side (not fabrication scars). If on fur, damage is on the inner surface; holes and loss of hair result from complete larval penetration of hide.
9. Termites	Cotton or hemp binding of wool rug eaten leaving the wool untouched. Hard mastic substance present.

3. Irregular or round holes in wool fabrics that may or may not penetrate the fabric with tips of exposed threads, usually being curled, would probably indicate damage caused by __________ __________.

4. The nap of wool missing in spots with the possibility of holes appearing completely through the fabric, and, if furs are involved, the hairs being cut at the base, causing loose fur and exposing the hide describes the damage most generally caused by __________.

5. Surveys for fabric pests are conducted to determine whether there is an __________ __________.

6. All __________ and clothing storage areas should be inspected __________ for further damages and __________ of __________, pupa skins, and/or __________.

7. While conducting inspections for fabric pests, you should pay close attention to all __________ areas such as the __________ and __________ of clothing, corners of __________ areas, and beneath and behind the __________ of __________ and __________.

A03. Given a series of statements, correct any that are false.

Control of Fabric Pests. Controls for fabric pests may be either preventive or corrective and may be in the form of nonchemical or chemical controls.

Preventive control. The best preventive control measure for protecting clothing against fabric pests attacks is to place the clothing in a cold storage facility when possible. This is particularly important when expensive furs are involved. When cold storage facilities cannot be used or are not practical, articles of clothing may be placed inside plastic bags along with paradichlorobenzene crystals (moth balls) and sealed. Although it is the least effective, another course of action that may be taken when clothing cannot be placed in cold storage or in bags is to distribute paradichlorobenzene crystals in the areas where clothing is stored.

NOTE: See Appendix A in the supplement to Volumes 4, 5, 6, and 7 for rate of application of paradichlorobenzene crystals, and insure that these crystals are placed out of reach of children.

Corrective control. Clothing that is infested with fabric pests may be rendered free of these pests (if they are in the adult or larvol stages) by placing the clothing in a very cold environment (near the freezing point) for a couple of days. Dry cleaning or laundering garments will generally kill all stages of development. If pesticides are required, clothing and other fabrics may be residually treated with an approved insecticide; of course, fumigation provides the best guarantee for a complete kill of all stages of fabric pests. While clothing and household furnishings are being treated, a residual should be applied to baseboards, floors, behind radiators, closet shelves, walls, and surface areas of carpeting.

NOTE: See Appendix A in the supplement to Volumes 4, 5, 6, and 7 for chemical control of carpet beetles and clothes moths. Remember, never substitute the recommendations found in this course for the information contained on pesticide labels.

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Exercises (A03):

Correct any false statements.

1. Controls for fabric pests may be in the form of nonchemical or chemical, but the controls must be preventive in nature.

2. Placing clothing, especially expensive furs, in a cold storage facility is the best preventive control measure for protecting clothing against fabric pest attacks.

3. When safely using paradichlorobenzene crystals as a preventive control measure in clothing areas, the crystals can be distributed at random.

4. Placing clothing in a very cold environment for a couple of days is an effective corrective control of fabric pests as long as these pests are in either the larval or pupal stages.

5. Approved insecticides may be used effectively for residually treating clothing and other fabrics as a corrective control measure for fabric pests.

6. Fumigation is an effective corrective control measure for fabric pests and can be accomplished by anyone who is assigned the 566XO AFSC.

1-2. Stored Food Pests

Stored food pests rob the citizens of the United States of approximately one billion dollars worth of stored food each year. This cost doesn't even take into account the damage to crops in the field or losses due to diseases of humans and domestic animals associated with these pests.

Stored food pests have been separated into five groups based upon their feeding habits: those that (1) attack whole grains, (2) attack broken grains, (3) attack beans and peas, (4) attack meats and cheese, and (5) are general feeders. You will learn about the habits, habitats, and control of these pests in this section.

A04. Distinguish between true and false statements concerning whole grain pests, and correct those that are false.

Whole Grain Pests. The pests discussed within this objective are those that principally infest whole grain.

Rice weevil. The rice weevil *(Sitophilus oryza)* is worldwide in distribution and is probably the most important grain pest. This small, reddish-brown to black snout beetle, 3.1 to 4.2 mm long, has small, round pits on the thorax and two reddish or yellowish spots on each wing cover. The larva is short, fat, and whitish. The adult is a strong flier. The larva and pupa develop within a single grain of rice or kernel of corn, from which the adult weevil emerges about 30 days after the egg is laid. The adult female lives 4 to 5 months, depositing 300 to 400 eggs in small openings bored into grain. The rice weevil feeds upon corn, rice, wheat, barley, and other grains. The rice weevil is a major pest in the south.

Granary weevil. This weevil *(Sitophilus granarius)* is similar to the rice weevil in appearance, but with oval pits on the thorax and with the wing covers uniformly dark brown. This insect has become thoroughly domesticated, losing its power of flight and forsaking wild and cultivated grain fields for grain storehouses. This snout beetle is slightly larger than the rice weevil and lives from 7 to 8 months. The granary weevil is primarily a pest of the north.

Cadelle. The cadelle *(Tenebroides mauritanicus)* is a black beetle, 8.3 to 12.5 mm long, with the head and pronotum distinctly separated from the forewings by a loose joint. The large, whitish, flesh larvae are about 19 mm long when fully grown and may be recognized by their prominent black heads, the paired black spots on the three segments of the thorax, and two short, dark hooks at the posterior end of the abdomen. Larvae burrow into the woodwork of grain bins. A seemingly clean bin may harbor thousands of larvae, pupae, and adults. The life cycle requires from 2 to 14 months, with many adults living more than a year. The females lay about 1,000 eggs in protected situations, such as in cracks near food. The cadelle feeds upon grain and grain products and does much damage to bolting silk in flour mills. It is especially injurious in unclean mills.

Lesser grain borer. The lesser grain borer *(Rhyzopertha dominica)* is a brown or black, slender, cylindrical beetle with numerous coarse elevations on the pronotum. It is about 3 mm long and is most common in the Gulf States, but may occur anywhere in the country. Both larvae and adults attack and destroy wheat kernels. The females lay up to 500 eggs each, dropping them in the loose grain. In warm weather, the life cycle is completed in about 1 month.

Angoumois grain moth. The Angoumois grain moth *(Sitotroga cerealella)* is a light grayish-brown or straw-colored moth with a satiny luster and wing expanse of 12.5 to 16.6 mm. The hind wings are fringed with long, dark setae and have a point at the tip like a finger. This feature distinguishes the insect from the clothes moth. The larva is white with a brown head. It is only 5 mm long and lives within the individual grain of wheat, corn, or other grain. It passes the winter in stored grain. The adult emerges and infests cereal crops either in the field or in storage and deposits about 40 eggs. The entire life cycle may be passed in 5 weeks. The Angoumois grain moth is second in importance to the rice and granary weevils as a pest of stored grain. It is of greatest importance in the South and in the soft, red, winter wheat region of the Eastern and Central States.

Exercises (A04):

1. Place the letter "T" in front of the correct statements.

___ a. The rice weevil is a small reddish-brown to black snout beetle with small, round pits on the thorax and two reddish or yellowish spots on each wing cover.

___ b. The adult rice weevil emerges about 30 days after the egg is laid.

___ c. The granary weevil is similar to the rice weevil in appearance, but it has oval pits on the thorax and the wing covers are uniformly dark brown.

___ d. The granary weevil often frequents the Southern States.

___ e. The cadelle is a black beetle with the head and pronotum distinctly separated from the forewings by a loose joint.

___ f. The lesser grain borer is a white or grey, slender, cylindrical beetle with numerous coarse elevations on the pronotum.

___ g. In warm weather, the lesser grain borer life cycle is completed in about 1 month.

___ h. The Angoumois grain moth is a light grayish-brown or straw-colored moth with a satiny luster.

___ i. The larvae of the Angoumois grain moth is black with a brown head and lives within the individual grain of wheat, corn, or othe grain.

2. Correct any false statements.

A05. Identify given statements pertaining to the descriptions, importance, and development of important broken grain pests as being true or false, and correct the false statements.

Broken Grain Pests. The pests discussed within this objective are those that principally infest processed grains, such as cereal, flour, and corn meal.

Confused flour beetle. The confused flour beetle *(Tribolium confusum)* attacks cereal products and is the worst insect pest of prepared cereals. It is a shiny, reddish-brown beetle, 3.6 mm long with a flattened, oval body. The head and the thorax are densely covered with minute punctures, and the wing covers are ridged lengthwise and are sparsely punctured between the ridges. The antennae gradually enlarges from head to tip. This beetle is not known to fly even though it has wings. Eggs are laid on the surface of the food with a sticky substance so that it becomes covered with the product. They will hatch in 5 to 12 days.

Red flour beetle. The red flour beetle *(Tribolium casteneum)* is very similar to the confused flour beetle in its life history, habits, and appearance. This similarity probably accounts for the naming of the confused flour beetle. Even though they are very similar, there are some morphological differences in the two. For example, the antennae of the red flour beetle ends with the last three segments being abruptly enlarged. Another difference is that the sides of the thorax are curved instead of being somewhat straightened as with the confused flour beetle. In addition to these differences, the red flour beetle can fly.

Mediterranean flour moth. The Mediterrranean flour moth *(Anagasta kuhniella)* prefers cereal products, but it will attack a wide variety of foods, including whole grain, bran, nuts, and dried fruits. It has a wingspread of less than 25 mm. The forewings are pale gray with transverse, wavy, black markings. The hindwings are a dirty-white color. The whitish larva (about 12.5 mm long with a brown head) lives in a silken tube, and its silk clogs machinery and tangles flour, nuts, chocolate, dried fruit, and other foods.

Indian meal moth. The Indian meal moth *(Plodia interpuctella)* prefers coarse grades of flour and milled products, but it will attack a wide variety of dry food products. This moth has a wingspread of about 19 mm and is easily recognized by the distinctive markings on the forewings. These wings are reddish brown with a coppery luster on the outer two-thirds and whitish gray on the upper third. The tiny, white, brown-headed larvae spin a silken thread that forms a loose webbing that is readily detected in heavy infestations.

Exercises (A05):

1. Place the letter "T" in front of the correct statements.

___ a. The confused flour beetle attacks cereal products and is the worst insect pest of prepared cereals.

___ b. The confused flour beetle is shiny, reddish brown, with a flattened, oval body.

___ c. The confused flour beetle is not known to fly even though it has wings.

___ d. The antennae of the red flour beetle ends with the last three segments being abruptly smaller.

___ e. The red flour beetle is not capable of flying.

___ f. The Mediterranean flour moth prefers cereal products, including whole grain, bran, nuts, and dried fruit.

___ g. Mediterranean flour moths are pale grey with transverse, wavy, black markings. The hindwings are a dirty-white color.

___ h Indian meal moths prefer fine grades of flour and milled products.

___ i. The forewings of the Indian meal moth are reddish brown with a coppery luster on the outer two-thirds and whitish gray on the upper third.

2. Correct any false statements.

A06. Provide details concerning the identification, life cycle, and feeding habits of important bean and pea pests.

Pests of Beans and Peas. Although there are several arthropods that attack beans and peas, there are only two that are significant to you. Both are weevils that are actually beetles (order Coleoptera) with snouts.

Bean weevil. The bean weevil *(Acanthoscelides obtectus)* is a short snout beetle that feeds upon stored beans and peas. The adult is approximately 3 mm long with reddish legs and a light olive-brown color, mottled with darker brown and gray. The body narrows evenly toward the head. The tiny, legless larva and pupa live within the bean, whereas the adult emerges from the bean and feeds upon other materials. The female deposits eggs in beans, both in the field and in storage. Six or seven generations may be completed in a year. As many as 28 weevils have been known to develop in one bean. The use of tight sacks has been found to afford considerable protection. Bean vines and other refuse should be burned in the field or plowed under to prevent propagation of this insect. The adults hibernate in fields and warehouses.

Pea weevil. This weevil *(Bruchus pisorum)* is similar to the bean weevil, but it is larger (5 mm long), brownish flecked with white, and it has black to gray patches of scales. There is one generation per year, the adults overwintering in peas in the field or in storage. Egg deposition occurs only in the field. House mice eat pea weevils by cracking open the infested pea, eating the weevil, and discarding the pea.

Exercises (A06):

1. The bean weevil is a short ____________ beetle that feeds on stored beans and peas.
2. The tiny, legless ______________ and ________ ____________ live within the bean, whereas the ________________ emerges from the bean and ________________ upon other materials.
3. The adult bean weevil hibernates in ____________ ______________________ and ______________.
4. The pea weevil is similar to the ________________ *weevil.*
5. *The pea weevil deposits eggs only in the* ______________________.

A07. Match meat and cheese pests with given statements concerning the identification, significance, and feeding habits of meat and cheese pests.

Pests of Meat and Cheese. This objective discusses the pests that infest principally the products of animal origin.

Larder beetle. The larder beetle *(Dermestes lardarius)* is about 8 mm long, dark brown, with a wide yellow band across the front part of the wing cover. The larva is brown, very hairy, tapering towards the ends of the body. This insect is worldwide in distribution. The eggs are laid on or near animal products, such as feathers, horns, skins, hair, ham, bacon, dried beef, and like products. The life cycle requires 40 to 50 days. This insect may be found in dog biscuits, cheese, museum specimens, dried fish, and stored tobacco. It is also known to penetrate lard.

Red-legged ham beetle. This insect *(Necrobia rafipes)* is a shiny blue to green beetle, 3.5 to 6.2 mm long, with reddish legs. It is especially troublesome in the Middle Atlantic States. The adults usually disperse by rapid running, but can fly. The mature larva is about 10 mm long, purplish, with six short legs, and tapers toward the head. The life cycle usually takes 36 to 150 days. The female lays 400 to 1,000 eggs on exposed meat. Thus, hams must be wrapped immediately after smoking. The larva can perforate grease-soaked paper wrappings. This pest lives primarily on dead and decaying animal matter, but it is sometimes reported in groceries and warehouses in smoked ham, bacon, garlic, bone meal, and other materials.

Cheese maggot. This pest is a fly *(Piophila casei)* about the size of a housefly and is often referred to as a cheese skipper. The adult is black with a bronze tint on the thorax. It has reddish-brown eyes and iridescent wings which lie flat over the body. The larva is a slender maggot, pointed toward the head end. The larva is able to skip as much as 10 inches horizontally and 6 inches vertically by curving its body into a ring, fastening its mouth hooks onto the end of its abdomen, suddenly releasing its hold, and throwing itself into the air. The life cycle of the insect is completed in 12 days under favorable conditions. The adult deposits 140 to 500 eggs over a period of 3 to 4 days. This insect infests ham and cheeses. The adults can transmit enteric diseases to man by contamination, and the maggots cause intestinal irritation when ingested with cheese. The recognized common name "cheese skipper" is very unfortunate for this pest, because skippers are mothlike Lepidoptera.

Exercises (A07):

Match the statement in column A with the pest in column B.

Column A

___ 1. This beetle is shiny blue with reddish legs.
___ 2. The larva is brown, very hairy, and tapers towards the end of the body.
___ 3. The adult is black with a bronze tint on the thorax, reddish-brown eyes, and iridescent wings which lie flat over the body.
___ 4. Eight mm long, dark brown, with yellow band across the front part of the wing cover.
___ 5. The larva has six short legs and tapers toward the head.
___ 6. The larva is a slender maggot pointed towards the head end.

Column B

a. Larder beetle.
b. Red-legged ham beetle.
c. Cheese maggot.

A08. Provided with true and false statements concerning general feeder pests, identify the incorrect statements by correcting them.

General Feeder Pests. Even though many of the stored product pests previously discussed may infest a variety of products, they are considered to be specific in food choice. This preference is not the case with the general feeders.

Saw-toothed grain beetle. The saw-toothed grain beetle *(Oryzaephilus surinamensis)* is an important pest known throughout most of the world. The adult is a small, active, brown beetle, 2.5 mm long, with a flattened body and six saw-toothed projections on each side of the thorax. The larva is yellowish white, about 3 mm long, with a brown head and an abdomen tapering toward the tip. The females live for 6 to 10 months, depositing 45 to 285 eggs in foodstuff. Several generations may occur each year, as the life cycle requires only 3 to 4 weeks during the summer. The saw-toothed grain beetle is an important pest in grocery stores, food warehouses, and grain storage. It readily penetrates packaged cereals, dried fruits, and candies. It also attacks flour, meal, sugar, drugs, dried meat, and tobacco.

Cigarette beetle. The cigarette beetle *(Lasioderma serricorne)* is principally a pest of tobacco, but it will feed upon many other products as was evidenced by its presence in the tomb of Tutankhamen in Egypt. This small, oval, light brown beetle is 2.5 mm long with smooth wing covers. The head is retracted beneath the thorax. The adult beetle flies readily. The larva is yellowish white, curved, very hairy, with a light brown head, and is about 4.2 mm in length. The life cycle requires from 6 to 12 weeks, and there may be 5 to 6 overlapping generations per year in warm localities, but there is only 1 generation in cooler areas. The female deposits as many as 100 eggs in tobacco, grain, milled cereals, and other products. This insect infests upholstered furniture, feeds, dried plants, drugs, black and red pepper, pyrethrum powder, raisins, rice, and many other commodities.

Drug store beetle. The drug store beetle *(Stegobium paniceum)* is similar to the cigarette beetle in appearance, but it is slightly larger (2.5–3 mm long), more elongate and has the wing covers distinctly striated. The last three segments of its antennae are sawlike. Its food is even more varied than that of the cigarette beetle, and it is said to feed upon "almost anything except case iron." It peculiar diet includes such odd materials as strychnine, belladonna, books, mummies, and lead.

Khapra beetle. This beetle is pale red to brown or black and is from 1.7 to 3 mm long. Females are much larger than males. The female lays up to 126 eggs, which hatch yellowish-brown larvae with long setae. The larva develops into a pupa and the pupa into an adult. The life cycle requires about 6 weeks during warm weather. The larvae may live for years without food. Khapra beetles *(Trogoderma granarium)* feed on dried vegetables or animal matter of all kinds. Only the southwestern United States is known to be infested at the present time. If you find any of these beetles, you must report them immediately to the U.S. Department of Agriculture.

Exercises (A08):

1. Correct any false statements below.

a. The adult saw-toothed grain beetle is a small, active brown beetle with a flattened body and four saw-toothed projections on each side of the thorax.

b. The saw-toothed grain beetle is yellowish white with a brown head and an abdomen tapered towards the tip.

c. The cigarette beetle is a small, oval light green beetle with smooth wing covers.

d. The cigarette beetle larva is yellowish white, curved, very hairy, with a light brown head.

e. The drug store beetle is similar to the khapra beetle in appearance.

f. The drug store beetle diet includes strychnine, belledonna, books and lead.

g. The female khapra beetle is much larger than the male.

h. The khapra beetle larva may live for years without food.

A09. Distinguish between true and false statements pertaining to the survey and collection of stored product pests, and complete other given statements.

Survey and Collection Techniques for Stored Product Pests. The dry stores area is probably the most overlooked food service area from an entomological point of view. The insects that infest dry stores may not be easy to discover in light infestations, but heavy infestations can be nauseating. The monetary loss of foods due to insect infestations can run into hundreds of dollars as well as depriving personnel of certain food items until replacements are available.

Surveys are a vital part of any pest management program. A good survey program not only allows you to control a current infestation, but helps you prevent future infestations. Make a visual inspection on all incoming goods that are susceptible to insects. If a heavy infestation is present at time of receipt, reject the load. A light infestation detected at this time would indicate a need for treatment before these items are stored.

The following guidelines for determining the fitness of insect infested subsistence items for human consumption have been approved by the Surgeon Generals of the military services.

a. When an infestation is found to include larval stages of an insect species belonging to genus *Trogoderma* or other dermestids, one insect within the product is justification for condemnation of the food product.

b. When an infestation is found to involve insect species belonging to the genus *Tribolium*, three insects per pound within the product container is justification for the condemnation of the food product.

c. When an infestation is found to involve insects other than those belonging to the genus *Trogoderma* (or other dermestids) or *Tribolium*, a maximum of six insects per pound of product is permissible.

d. For all resale subsistence to be sold at military commissary and/or exchange outlets: any insect found within a subsistence product container is justification for the condemnation of the food product.

Most insects have a very high reproductive potential which, combined with a short cycle, permits an incipient infestation to become damaging within a short period of time. The inspector (base veterinarian or other designated official) should regard each new shipment as suspect and should not assume that the apparent absence of insects means that none are present. Cereals with less than one insect per pound may become heavily infested within 30 days, requiring that the cereals be sold for animal feed or destroyed. Early detection of insect infestations plus prompt control measures make it possible to save valuable food stocks. Should destructive pests be found, sample the contents to determine the condition of the food and the abundance of infesting insects.

To conduct an inspection and collect stored product pests, you need a flashlight, vials and pillboxes, hand lens, and suitable samplers. A sampler, or "thief" is a tool for removing coffee, corn, rice, or other products from a sack without damaging the sack. It is usually not practical to sample closed cartons or food in multiwall bags unless there is good reason to suspect infestation. If food is not kept in these types of containers for long periods of time, the danger of loss is small.

Make inspections throughout the warehouses at weekly intervals during the warm months and at monthly intervals during the cool months. Stop at each location where susceptible food is stored. Canned foods, sugar, and other items not highly susceptible to damage are usually bypassed or given a quick examination. Examine carefully beans, hams, cereals, and improperly packaged cheeses. It is a good practice to check windows for flying insects and to examine floors, pallets, and walls for insects that have emerged. Insects affecting sacked grains and cereal products are found on the exterior of the bags and at the ends where the bags are stitched. Use the flashlight in examining these locations, and collect specimens for identification. The lot number of each shipment is recorded in a notebook, together with the date of receipt, origin of the shipment, date the infestation was discovered, and name of the inspector.

Items may be inspected while they are in freight cars or on loading platforms before they are placed in storage. One inspection method used is sampling from some of the packages and placing the food in incubators so that insects may emerge and be detected. A method of detecting feces in flour is to shake the flour in a flask with a saturated salt solution containing gasoline (35 ml of gasoline; 200 ml of salt solution; 50 g of flour). Allow the flask to stand for 30 minutes. Stir at 5-minute intervals without disturbing the gasoline layer. Use a trap flask to collect floating material, and examine this material for insect and rodent feces.

Exercises (A08):

1. Place the letter "T" in front of the true statements.

___ a. If a visual inspection reveals a heavy infestation present at the time of receipt, the lot should be rejected.

... b. Condemnation of the food product is justified if you find one insect in the larval stage of species belonging to genus *Trogoderma* or other dermestids.

___ c. Condemnation of food products is justified if you find two insects belonging to the genus *Tribolium* per pound within a product container of insects.

___ d. When an infestation is found to involve insects other than those belonging to the genus *Trogoderma* or *Tribolium*, a maximum of three insects per pound of product is permissible.

___ e. Warehouses should be inspected at weekly intervals during the warm months and monthly intervals during the cool months.

2. Early detection of insect infestation plus ________ control measures make it possible to save valuable ________ ________ stocks.
3. To conduct an inspection and collect stored product pests, you will need a ________, ________ ________, ________, and suitable ________.
4. ________, ________, ________, and improperly packaged ________ should be examined carefully.
5. Insects affecting sacked grain and cereal products are found on the ________ of bags and at the ________ where the bags are ________.
6. The lot number of each shipment is recorded in a notebook, together with the ________ of receipt, ________ of shipment, ________ infestation was discovered, and ________ of the inspector.
7. One inspection method used in sampling some of the packages and placing the food in ________ so that insects may ________ and be ________.

A10. Complete given statements concerning various preventive control measures for stored product pests, and identify the type of preventive control that the statments describe.

Preventive Control of Stored Product Pests. Some people's custom of storing food for later consumption provides insects and easy living. Some pests live in the fields and fly into storehouses or are transported in with infested food. Others live only in stored foods and invade fresh material which is brought in. If the storehouse provides favorable moisture, temperature, and harborage, not only may tremendous economic loss result, but people are exposed to insect-borne disease. Stored product pest control should be conducted on a year round basis. Prevention is the best way to control stored product pests. There are several ways to prevent these pests, including:

- Sanitation.
- Palletizing.

- Rotation.
- Isolation.
- Ventilation.
- Packaging.
- Insectproof construction.

Sanitation. Cleanliness is an important factor in preventing insect damage to stored products. Many warehouses have become highly infested because flour, rice, or other foods have been spilled on the floors and allowed to remain for long periods of time to reinfest each new shipment of clean merchandise placed in storage. It is essential that all torn bags be repaired immediately, that floors be kept clean, and that efforts be directed toward preventing contamination of stored food products.

Palletizing. Do not allow the placing of cartons, bags, and other containers of goods directly upon the floor. Oak or pine pallets should be employed to store these items, each pallet containing a load that can be transported from place to place by hydraulic lift. Cartons or bags should be placed upon the pallets by hand labor, but after this operation, machinery can be used to transport the palletized stocks from place to place. There is a trend toward shipping material on pallets so that the merchandise can be loaded and unloaded by machinery. Cereal products or other foods must not be stacked against warehouse walls or ceilings, as this placement prevents adequate inspection and creates a fire hazard. Stacking food products against the walls also increases the amount of rodent harborage. Stacks should not be so high that they crush cartons and bags, as this practice also will increase the probability of infestation.

Rotation. Rotation of stocks is an important factor in preventing losses due to insects. If old stocks are allowed to remain in storage for long periods of time, the insects may complete one or more life cycles, and light infestations may become damaging ones. Old stocks remaining on hand may infest stocks subsequently received. The accumulation of dirt and filth, rodent urine or feces, and moisture may result in the eventual loss of valuable foodstuffs. Food stored under such conditions is especially subject to insect attack, and the formation of mold may impart an off-flavor.

Isolation. It is important to isolate new stocks of susceptible items from the old supply. Often a carload of feed or flour is stacked on or near a few remaining sacks of old infested materials. This placement results in the immediate infestation of the new shipment. Susceptible items must be stored as remotely as possible from old stocks, whether the infestation is heavy or light, or even if the material is believed to be free from infestation

Ventilation. Adequate ventilation is important in the storage of dry foods. A high moisture content is conducive to attack by insects and mites and the formation of mold. Ventilation may be provided by 3-foot access aisles between stacks and the walls, and 2 feet between the stacks and the ceiling. Ventilators and doors should be opened during dry weather and closed during periods of excessive humidity. During the winter, it is advantageous to permit cool air to circulate in warehouses unless this air may cause damage to products subject to freezing. Grains may be subjected to extremely low temperatures without damage. Cold is a useful factor in deterring insect infestations, as most species develop slowly at low temperatures and many individual insects are killed by freezing temperatures.

Packaging. The careful packaging of subsistence items can greatly limit insect infestations in stored food. Generally, it is best not to reuse packaging. If packaging is to be reused, it must be sterilized by heat or fumigation.

Insectproofing. Grain stored in poorly constructed buildings may become infested by insects flying in from nearby fields or warehouses. Poor construction encourages rapid buildup of large populations. Carefully planned and constructed warehouses can minimize this hazard. Make the building as insectproof as possible.

Exercises (A10):

1. The seven preventive control measures of stored products pests are ____________, ____________, ____________, ____________, ____________, ____________ ,and ____________.

2. It is essential that all ____________ bags be ____________ immediately, that floors be kept ____________, and that efforts be directed toward preventing ____________ of stored ____________ products.

3. What type of preventive control measure is applied to the above statement?

4. Proper practice in food storage does not allow placing ____________, ____________, and other ____________ of goods directly upon the ____________.

5. What type of preventive control measure is applied to the above statement?

6. If old stocks are allowed to remain in storage for ____________ periods of ____________, the insects may complete ____________ or ____________ life cycles.

7. What type of preventive control measure is implied in the above statement?

8. Susceptible items must be stored as __________ as possible from old __________ , whether the infestation is heavy or light, or even if the material is believed to be free from infestation.

9. What type of preventive control measure is applied in the previous statement?

10. Doors and ventilators should be __________ during dry weather and __________ during periods of excessive humidity.

11. What type of preventive control is applied in the previous statement?

12. Sterilization by heat or fumigation is necessary if __________ is to be reused.

13. What type of preventive control measure is applied in the previous statement?

14. Carefully __________ and __________ warehouses can minimize infestation caused by insects flying in from nearby fields and warehouses.

15. What type of preventive control measure is applied in the previous statement?

A11. Complete given statements pertaining to the corrective control of stored product pests.

Corrective Control of Stored Product Pests. Once stored foods have become infested with insects, they must be controlled to prevent the spread of these insects and to reduce further damage. The corrective methods that you can use to control stored product pests is the subject of this objective.

Radiation. Radiant energy has been used experimentally to eliminate pests from stored food and in a limited way in food plants. This technique may become a commonly used method for stored food pest control in the near future.

High frequency electric fields. Stored product pest control through selective heating by high frequency electric fields has been accomplished experimentally and shows promise as a method of eliminating insect eggs from stored foods.

Biological. Parasitic wasps *(Anisopteromalus calandrae, Caphalonomia tarsalis, Bracon hebetor, Idechthis canescens,* etc.), fly larvae *(Omphrale fenestralis, Omphrale globrifrons,* etc.), and mites (straw itch mites, floricolus grain mites, etc.) prey on stored-product insects and can be effective in limiting an infestation. A crab spider, *Thanatus peninsulanus,* is commonly found preying upon stored food pests.

Residual spraying. Residual spraying in subsistence warehouses should be restricted to walls and floors only. Use only those chemicals that are recommended. Be sure to follow all label instructions as each pesticide is registered with EPA only for those uses listed on the label. The label is the law.

Space spraying. Space sprays consisting of approved insecticides (see appendix A of supplement to Volumes 4, 5, 6, and 7 may be applied by using ultra-low-volume dispersal equipment. This equipment fills the air with tiny droplets of insecticide that kill insects in flight or upon exposed surfaces. This method also helps kill these pests between pallets, bags, and in other locations. Such treatments do not constitute fumigation and are feasible only for destroying insects that have not penetrated bags and cartons. These treatments are regarded as preventive maintenance rather than as a means for eliminating existing infestations.

Fumigation. Fumigation of stored products is the traditional means for destroying all insects infesting bins, elevators, warehouses, and storerooms. Fumigation is dangerous and should be attempted only by qualified personnel.

The in-transit fumigation program should drastically reduce infestations of products arriving by rail, but this does not mean that you should curtail your survey programs. In addition to the intransit fumigation mentioned earlier, in-place (stack) fumigation may also be used. Fumigation with aluminum phosphide kills all stages of the pests involved, and if proper procedures are followed, it is a safe and economical method of eradication.

Fumigation is usually accomplished in containers, vaults, buildings, or box cars at atmospheric pressure. More satisfactory treatment can be obtained in vacuum chambers especially developed for fumigation purposes. These installations are very expensive and are not available in all areas. Bagged and packaged materials may be completely disinfested of live insects by vacuum fumigation (methyl bromide will penetrate to the center of a 200-pound sack of flour or through cartons used for packaging cereals). These fumigations are not completely effective at atmospheric pressure, and vacuum chambers are recommended. Fumigated items must be placed in proper storage after treatment. As insect eggs are not always killed, stocks are susceptible to reinfestation. It is not desirable to fumigate the same items repeatedly.

After a warehouse has been freed of stored product pests, it is very important to examine all incoming stocks carefully to avoid introducing new infestations.

Reclamation. Reclamation is a term used to denote the processing of materials in order to prevent severe losses, providing the infested items will pass the standards of the Food and Drug Administration. Immediate fumigation of lightly infested materials will often suffice, but heavily infested materials can rarely be put to use as human food. Flour may be rebolted to remove most of the infesting insects, but the minute fecal matter and eggs are not removed. Hams infested by cheese maggots may be trimmed and repackaged in order to maintain them in a salable condition. Cereal products may be fumigated and repacked in multiwall sacks to prevent further damage. It is good practice to use multiwall bags for cereal products that are to be shipped overseas to the tropics in the holds of ships, making conditions favorable to insects. Military products are often stockpiled overseas under conditions which subject them to high temperature and humidity over a period of time.

Exercises (A11):

1. Use of ______________ energy to eliminate pests from stored food has been used experimentally.
2. Space spray consisting of approved insecticides may be applied by using ______________ ______________ dispersal equipment.
3. The pesticide used for ULV application in indoor space treatment is ______________.
4. Fumigation with ______________ ______________ will kill all stages of the pest involved, and if proper procedures are followed, it is a safe and economical method of eradication.
5. More satisfactory treatment can be obtained in ______________ chambers especially developed for fumigation purposes.
6. Immediate fumigation of ______________ infested materials will often suffice, but ______________ infested materials can rarely be put to use as human food.
7. Cereal products may be ______________ an ______________ in multiwall sacks to prevent further damage.

Structural Pests

STRUCTURAL pests are the most important pests, from an economic standpoint, on military installations. These pests include fungi, termites, powder post beetles, carpenter bees, and carpenter ants. You must be very familiar with these pests because it is your responsibility to prevent pest damage to all base facilities, power line poles, and telephone poles. Your duties include conducting frequent inspections as well as taking preventive and corrective actions in maintaining structures free from structural pests.

This chapter will provide you with information pertaining to the importance, descriptions, and general characteristics of the more important structural pests and will describe the preventive and corrective controls that you can use to maintain base structures free from destructive fungi, termites, powder post beetles, carpenter bees, and carpenter ants.

2-1. Wood-Destroying Fungi

Wood is an abundant, versatile, and relatively inexpensive material. However, unprotected wood and wood products in use and in storage are subject to the destructive effects of fire, mechanical damage, insects, marine borers, moisture and weathering, and decay fungi. Of all of these, decay fungi causes the greatest losses. All of the "dry rot," "wet rot," and "natural deterioration" of wood is caused by living decay fungi. All can be prevented through recognition of the characteristics and biology of fungi, by knowing the conditions that are conducive to fungi growth, and being knowledgeable of the methods that may be implemented in the control of fungi. You have probably seen wood-rotting fungi as mycelial mats in the reproductive stages, as mushrooms, toadstools, and bracket fungi. However, by the time these surface growths are formed, extensive damage has been caused by the microscopically small mycelial threads (hyphae) which have penetrated deep within the wood. For this reason, you must learn to recognize signs of early attack by fungi, and to differentiate between the fungus damage and the destructive effects of moisture and weathering.

A12. Complete given statements concerning the classification, characteristics, and reproduction of fungi; identify other statements as being true or false.

Recognition and Classification. Fungi belong to the division Thallophyta of the cryptogamic plants. There are five major classes of fungi. One of these, class Basidiomycetes, contains the order Hymenomycetales, which is composed of five families. All five of these families have genera containing wood-destroying species. Some 2,000 species of wood-rotting fungi are known, of which 200 to 300 are commonly involved in wood deterioration on a serious scale.

Because laboratory procedures are normally required for the specific identification of the wood-rotting fungi, it is fortunate that their identification by genus and species is not required to prevent the destruction of which they are capable. However, these fungi are easily organized into an "artificial" system of classification based on the destruction they do. This system is dependent upon the metabolic processes of the fungi, upon the composition of the materials on which or within which they grow, and upon the rates and methods of growth. By the use of this system, all fungi on wood in storage or in use may be identified as being mold fungi, stain fungi, or wood-rotting fungi.

Mold fungi. These may infect wood in storage or in use. Wood-inhabiting fungi require both moisture and air within the wood and that each is in excess of 20 percent of the dry weight of the wood. The mold fungi in wood enzymatically break down and utilize only such materials as starches, sugars, gums, and oils, and have no direct effect upon the cellulose and lignin. The hyphae of most molds penetrate the wood through existing pores and pits, and usually have no direct chemical or mechanical effects upon the cell walls. In removing nonstructural elements of the wood, molds often reduce any natural water repellency and make the wood more subject to wetting and to decay. Mold fungi may be found on the surface of wood which is being attacked at depth by decay fungi.

Stain fungi. Stains of various types may be produced in wood by some of the deep mold fungi, and will range from nearly black through shades of blues, browns, reds, and yellows. Of all the wood stains, the blue stain, or sap stain, is probably the most common and is the most serious. In the wood rays, in which the food substances are concentrated, the causal fungi can seriously damage the cell walls and weaken the wood mechanically.

Wood-rotting fungi. These normally begin on the surface or in checks or other openings, later penetrating to depth, where considerable destruction can result. In the initial or incipient stages, the hyphae spread in all directions through the wood. Unlike the hyphae of mold fungi, which pass from cell to cell through naturally existing holes, the hyphae of rot and decay fungi pass through "bore holes" which form at the cell walls at points of contact with the tips of growing hyphae. During the incipient stages there is no apparent dissolution of the wood other than at the microscopically small bore holes, nor are there visible changes in its characteristics other than the slight discolorations caused by some species. These discolorations may be easily overlooked, or may be mistaken for the color changes caused by mold fungi, chemical staining, or weathering. As decay progresses beyond the incipient stages, the appearance of the wood may be altered more and more perceptibly. In the advanced stages of decay, the wood may become punky, spongy, stringy, ring shaked, pitted, or crumbly, depending on the species of wood and of fungus, and upon the extent of fungal development. The wood-rotting or decay fungi are usually thought of as belonging to three major groups: the white rots, the brown rots, and the water-conducting fungi.

a. White rots of wood and wood products are caused by those fungi that are enzymatically capable of attacking the ligno-cellulose complex of the cell walls and degrading the lignified material. Because of the slight color changes usually involved, the white rots may at times be difficult to see. Some have dark brown or black zone lines at the areas of incipient decay which may be the only visual evidence of white-rot damage.

b. Brown rots of wood are caused by those decay fungi that can attack the ligno-cellulose complex, but which are incapable of degrading the lignin. The brown-rot fungi destroy the cellulose, but leave the lignin and some other materials as a brownish residue, which, when dry, may be easily crumbled into a powder. Not infrequently the brown residue is found in a dry rather than a moist condition, a situation which has led to the widely used, though inappropriate, term "dry rot." It should be remembered that the rotting of wood requires the activity of wood-rotting fungi and that these living organisms require for their development a moisture content of greater than 20 percent. After a period of initial growth, many of the brown-rotting fungi can develop structures highly resistant to desiccation. Some survive for several years in air-dry wood and severely damage wooden structures that are only intermittently exposed to moisture. For this reason, the use of infected wood for the construction or repair of buildings can be harmful or even dangerous.

c. Water-conducting fungi are brown-rot fungi that can conduct water from a single source to otherwise dry structural wood. The two most important water-conducting fungi are *Merulius lacrymans* and *Poria incrassata*. *Merulius lacrymans* is the most common building decay fungus in northern Europe, and is occasionally found in the northern United States. Poria incrassata, commonly called building poria is more tolerant of elevated temperatures, and is 5
consequently the more common of the two important water-conducting fungi in the United States. The initial growth may take place in cellulose material in 6
most soil beneath structures. The ability of the building poria to extend its growth over the surface of 7
inorganic materials permits it to bridge foundation walls and to reach the wood above them. Its tendency to first attack unexposed surfaces and its ability to conduct moisture to heights of more than 20 feet are responsible for the extent of the damage that may be done before any destruction is readily evident.

Life and History of Destructive Fungi. You should not forget that fungi are living organisms. They are plants that have lost their ability to utilize sunlight for the production of their foods.

Spore distribution. Fungi do not produce true seeds containing many-celled embryonic plants; they produce single-celled spores from which new individual plants develop. Most fungus spores are of microscopic size, lightweight, resistant to extreme conditions of temperature and humidity, and readily dispersed by wind and water. Fungus spores and even the fungus hyphae are easily carried from the ground and from infested wood to sound wood by wood-inhabiting insects.

Germination and growth. When the correct environmental conditions of humidity and temperature exist, a fungus spore germinates with the development of a hyphal tube or filament. If only water and inorganic materials are present, the growth will stop after the organic materials concentrated in the spore have been used up. The presence of the correct nutrients, such as the cellulose in wood, permits the further growth and branching of the hyphae and the formation of the *mycelial thallus* and the spore-bearing structures, such as bracket fungi, toadstools, mushrooms, and puffballs.

Physiology and metabolism. The physiology of the fungi differs from the physiology of green plants in that fungi, lacking chlorophyll, are incapable of synthesizing organic nutrients from dissolved inorganic materials. In the parasitic fungi, the mycelium penetrates living cells or the spaces between them and absorbs the intracellular or intercellular fluids of the host organisms. Most saprophytic fungi, such as those that decay wood, secrete substances that dissolve some or all of the solid organic materials on which the fungi are growing. All or some of these dissolved or "digested" materials are then absorbed by the hyphae and used for growth and development. Most of the wood-rotting fungi produce an acid reaction in various types of culture media; pH values as low as 2–3 are not uncommon. In the failure of structural concrete at points of contact with rotting wood, the effect of fungus-produced acids should be considered. Other metabolic products are also formed, and with the acids, destroy wood and other materials.

To a lesser extent, the purely physical effects of fungal growth may also destroy useful materials. Mildew and mold fungi are found on a great variety of both living and dead organic materials.

Exercises (A12):

1. Place the letter "T" before each true statement.

___ a. One of the classes of fungi is Basidiomycetes.
___ b. Wood-inhabiting fungi require both moisture and air within the wood and that each is in excess of 40 percent of the dry weight of the wood.
___ c. In removing nonstructural elements of wood, molds often reduce any natural water repelling and make the wood more subject to wetting and decay.
___ d. Mold fungi may be found on the surface of the wood which is being attacked at depth by decay fungi.
___ e. Of all the wood stains, the blue stain, or sap stain, is probably the most common and the least serious.
___ f. The ability of the building poria to extend its growth over the surface of inorganic materials permits it to bridge foundation walls and to reach the wood above it.
___ g. Fungi produce true seeds containing many-celled embryonic plants.
___ h. The physiology of the fungi differs from the physiology of green plants in that fungi, lacking chlorophyll, are incapable of synthesizing organic nutrients from inorganic materials.
___ i. Most of the wood-rotting fungi produce an alkaline reaction in various types of cultural media.
___ j. Mildew and mold fungi are found on a great variety of both living and dead organic materials.

2. Correct any false statements.

3. By using the artificial system of classification, all fungi on wood in storage or in use may be identified as being ______________ fungi, ______________ fungi, or ____________ fungi.

4. Mold fungi in wood enzymatically break down and utilize only such materials as ____________, ____________, ______________, and __________, and have no direct effect upon ______________ and ______________.

5. Stains of various types may be produced in wood by some of the deep mold fungi and will range from nearly ______________ through shades of __________, ____________, ______________, and ______________.

6. The wood-rotting or decay fungi are usually thought of as belonging to three major groups: the ________________, the ______________, and the ________________ fungi.

7. White rots of wood and wood products are caused by those fungi which are enzymatically capable of attacking the ________________ complex of the cell walls and degrading the ________________ material.

8. Brown rots of wood are caused by those decay fungi which can attack the ________________ complex, but are incapable of degrading the ________________.

9. The brown rot fungi destroy the ______________ but leave the ______________ and some other materials as a ______________ residue which, when dry, may be easily crumbled into a powder.

10. Water-conducting fungi are ____________ fungi which are able to conduct water from a single source to otherwise dry structural wood.

11. When the correct environmental condition of ______________ and ____________ exist, a fungus spore will germinate with the development of a hyphal ____________ or ______________.

12. Most saprophytic fungi, such as those which decay wood, ______________ substances which ______________ some or all of the solid organic materials on which the fungi are growing.

A13. Identify as true or false given statements concerning the measures that you can use to control wood-destroying fungi.

Wood-destroying fungi can be controlled effectively through (1) frequent inspections to detect the presence of fungi or conditions that are conducive to fungi growth, (2) initiating preventive measures to deter fungi growth, and (3) implementing corrective actions to eliminate fungi growth.

Inspection. The wood in the buildings at military activities should be inspected at least annually, and semiannually when possible or warranted, to determine the presence and extent of insect and fungus infestations and the type of control required. This inspection is often made in conjunction with the inspection for termite attack. Particular attention should be given to locations where the occasional presence of moisture from condensation or precipitation permit the growth of wood-rotting fungi. Crawl spaces under basementless buildings permit access for the inspection of structural timbers below the floor level. Wood in contact with masonry or metal subject to moisture condensation presents special hazards. Window and door frames and porch columns and railings should be given special attention, as heavy coatings of paint may hide conditions of rot. The use of a sharp pointed probe is advised in making these inspections. When inspecting wood in use, you should not neglect the pallets used in the storing of supply items.

Preventive Control. Preventive control of wood-destroying fungi can be divided into two categories from the standpoint of pest control personnel at base level: *wood in storage* and *wood in use*.

Protection of wood in storage. Lumber in storage can be protected from fungus damage and the destructive effects of moisture changes through proper storage management and dip-treating untreated lumber.

Lumber should be stored off the ground or flooring and under a protective overhead shelter. It should be stacked with a slight space between each board and elevated slightly at one end to allow ventilation and water runoff. These storage methods are discussed in considerable detail in AFM 67-3, *Storage and Materials Handling*.

A quick dip treatment of stored lumber with water-repellant pentachlorophenol will provide protection during a long storage life where the wood must be exposed to the weather. Before it is dip treated, the lumber should be stickered and baled ready for storage, and it should be dried to a moisture content of no more than 20 percent.

Protection of wood in use. Structural wood in use often requires protection from destructive fungi. The theories involved and used in planning control are based upon the growth requirements and physiology of the fungi, and are thus like those involved in the protection of lumber in storage. The actual practices employed to prevent decay, however, are different. Preventive control is based upon the use of preservatives and upon the control of moisture due to condensation, to the puddling of rain water, and to capillarity or seepage. Preventive control should begin with the planning and design of a given structure. Since our buildings now exist, it is too late to change the original designs. However, it is not too late to make some of the structural modifications needed to prolong the useful life of our buildings. This is particularly true when repair work is required as the result of the destructive actions of fungi. When it is noted that a particular design feature existing in several building has been in part responsible for fungus damage, consideration should be given to minor modifications of the others before expensive repairs are required. Proper design begins at or below the ground level and provides for drainage away from the structure. At some activities, there are buildings under which rain water collects. This situation must be corrected if the buildings are to be saved. Even with adequate drainage, condensation on the sills, joists, and subflooring of basementless buildings may be so severe as to result in rapid deterioration.

a. Ventilation. It is important to maintain ventilation of the crawl spaces under basementless buildings (and in those with incomplete basements). The following formula for ventilation will normally be adequate if there are no pockets of stationary air permitted in corners or behind interior foundation walls. This formula is called the 2' plus 1/3' formula. It requires that the crawl space vent opening have a net unobstructed area equal to 2 square feet for each 100 lineal feet of outside wall plus 1/3 square foot for each 100 square feet of crawl space area. Obstructions require larger openings. If the vents are covered with louvers or 1/16-inch mesh insect screen, the size should be doubled. If they are covered with both, the size should be tripled. If the gross area is partially covered by bars, grills, or grids, it should be adjusted to permit an adequate net area. The practice, employed at some activities, of entirely closing the vents during cold weather will lower the fuel bill, but will increase the maintenance costs and shorten the useful life of our structures.

b. Ground cover. In areas where the expense of comfortably heating occupied buildings provided with adequate ventilation of the crawl spaces seems prohibitive, the employment of another condensation-prevention technique may be desirable. A method which has proven successful involves the use of a soil cover. Asphalt roll roofing of the grade that weighs 55 pounds per roll of 108 square feet has proven satisfactory. No lapping, fastening, cementing, or preliminary careful leveling is required. Plastic films are also effective. They are easier to handle, but require weighting at the corners.

c. Protection from water. Most cases of serious decay in siding and exterior trim are found on buildings having little or no roof overhang or with faulty eaves, gutters, or downspouts. Excessive amounts of water run down the sides and seep into joints, particularly butted joints between siding pieces and between siding and trim. It is nearly impossible to maintain joints sufficiently tight to exclude seepage water during severe rain washings. Paint cannot be depended upon to seal joints. In many areas, the siding and trim containing appreciable amounts of sapwood require protection by the following: (1) good projection of eaves and rake of gables to prevent all but occasional rain washing; (2) tight joints plus well maintained paint films to minimize rain seepage during occasional wettings; (3) lightweight, vapor-permeable (breathing) building papers under siding to hasten the drying of any seepage water; (4) good flashing of exposed doors, windows or other openings, and any horizontal projections; and (5) the use of eaves, gutters, and downspouts. When rain washing cannot be prevented, preservatives should be used.

d. Building appendages. Wooden porches and exterior steps, even when of the best design and construction, are decay hazards, and any feature promoting seepage will greatly hasten decay. Step and stoop rails if protected by well-maintained painted surfaces, exhibit marked differences in susceptibility to decay, depending on the type of construction. Considerable protection is afforded by extending the rail over the top of the newel rather than abutting the end of the rail to the side of the post. Any rail splice occurring over a post will greatly increase the decay hazard. These design features should be considered during inspections and when replacement is required. The common practice of placing trim over the ends of drop siding normally creates no decay hazard, but instead allows less water seepage than the common butt joints of siding to trim. With bevel siding, the placement of trim over the siding ends tends to reduce wetting, but not to any great degree. The bevel results in a long vertical opening and allows easy water flow back under the siding. With bevel siding, metal corners are the only structural means of reducing water seepage; all other types of corner joints leak badly.

e. Wood preservatives. Because there are no design modifications that can prevent all decay if roof overhang and ventilation are insufficient, the use of preservatives is advised. When badly rotted wood is found, it should, of course, be replaced. In all cases, preservatives should be used, and in some cases, preservation to depth must be employed. Because of the seepage factors involved and the probable incipient rot in the wood adjacent to that replaced, the use of surface preservation is advised. After a rotted [illegible] of wood is removed, and before it is replaced, [illegible] structural wood still in place in the area of decay should be saturated as thoroughly as possible by brushing or spraying on a water repellent 5 percent pentachlorophenol solution in mineral spirits. Three or more brushings may be required. To permit penetration of all treatments after the first, apply them before the solvent has dried and the water-repellent material has sealed the wood against further absorption. Building sidings that require painting may be easily treated with a preservative before the paint is applied, the water-repellent material in the preservative acting as a prepaint wood primer. Brushing on of all the preservative that can be absorbed in window frame and sash is advised in all cases before renewing the paint. Power sprayers provide a ready means of treating susceptible areas under basementless buildings. The heavy application of a water repellent 5 percent pentachlorophenol solution can make the structural timbers, even at their joints, almost completely impervious to water and, therefore, safe from the destructive effects of decay fungi. In the preservative treatment of structural wood in place, pay particular attention to all joints and to wood in contact with concrete, brick, metal, stone, and other surfaces on which moisture tends to condense even more readily than on wood. The application of preservatives to wood in place will be most effective when the wood is dry; it is a job which should be, whenever possible, saved for dry weather. Preservative emulsions and greases are suitable for use in many locations, but they may affect the paintability of wooden siding and trim.

Corrective Control. Corrective control of wood-destroying fungi can also be divided into two categories: protection of wood in storage and of wood in use.

Protection of wood in storage. Wood found to be fungus infested in storage should be removed from clean lumber, and should [illegible] handled as explained in the paragraphs discussing preventive treatment. It should in no case be allowed to remain untreated in a lumber yard.

Protection of wood in use. Seriously rotted wood can only weaken the structure of which it is part; it should be replaced. Lightly damaged wood may be at least partially protected by the use of preservatives as discussed in preceding paragraphs. Attempts to pressure-treat wood in place by applying fungicides or insecticides under pressure to drilled holes will consistently produce poor results. Deep penetration can, however, be obtained by the surface application of grease or emulsion formulations. In the control of water-conducting fungi, give special attention to the moisture source. The use of water-soluble fungicides may be advisable at such points. Though it may be desirable in some cases, it will rarely be necessary to use wood preservatives at the points to which these specialized fungi have conducted moisture, provided the rhizomorphs are completely destroyed and their lower portion poisoned with fungicides.

Exercises (A13):

1. Place the letter "T" before the true statements.

___ a. Wooden buildings at military activities should be inspected at least annually, and semiannually when possible or warranted, in order to determine the presence and extent of insect and fungus infestation and the type of control needed.

___ b. Lumber should be stored off the ground or flooring and under a protective overhead shelter.

___ c. A quick dip treatment of stored lumber with water-repellent pentachlorophenol will provide protection during a long storage life where the wood must be exposed to the weather.

___ d. Preventive control is based upon the use of preservatives and upon the control of moisture.

___ e. The closing of vents under basementless buildings in cold weather will lower the fuel bill, decrease the maintenance cost, and extend the useful life of structures.

___ f. A condensation-prevention technique used under buildings makes use of a soil cover if adequate ventilation cannot be provided.

___ g. Most serious decay in siding and exterior trim is found in buildings having little or no roof overhang or faulty eaves, gutters, or downspouts.

___ h. Wood porches and exterior steps are decay hazards.

___ i. A 5 percent pentachlorophenol solution in mineral spirits may be used as a wood preservative.

___ j. Preservative emulsions and greases are suitable for use as wood preservatives.

2. Correct all false statements.

2-2. Termites

In your job, you will more than likely be spending a lot of time on the job inspecting base facilities for termites and then controlling them. It is a part of your responsibility to prevent damage that may be caused by termites whenever possible as well as to detect early infestations and take the necessary action.

It is for these reasons that this section provides you with information pertaining to the importance, types, general characteristics, caste systems, colony development, and requirements of termites.

A14. State the beneficial and damaging traits of termites.

Importance of Termites. Termites are the most destructive insect pests at military activities. They may so severely damage a building as to be responsible for its condemnation. They eat wood and other cellulose products, such as paper, cardboard, and fiberboard, and will destroy structural timbers, pallets, crates, boxes, tool handles, furniture, books, and other wood products. Also, in their search for food, they will damage many materials that they don-t normally eat. In tunneling through the ground, subterranean termites will penetrate lead-covered and plastic-covered electrical cable, and thus will cause shorting out of electrical systems.

Although termites are very destructive, they are an important part of ecology in that they help microbial organisms break down wood and other cellulose materials into humus.

Termites may live for years in buried tree stumps or form lumber beneath concrete buildings, and then penetrating hairline cracks in floors and walls as well as expansion joints suddenly erupt in search of edible materials such as may be found in interior door frames and rarely moved furniture, such as file cabinets and bookcases. In attacking packaging and crating in storage areas, they will seriously damage such stored items as nylon parachutes and woolen clothing. On their bodies, they carry fungus spores from the soil and thus contribute to structural decay.

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Exercises (A14):

1. How do termites rank among the destructive insect pests at military activities?

2. What types of substances do termites eat?

3. In what way are termites beneficial?

4. How severely can termites damage buildings?

5. In what way do termites contribute to structural decay?

A15. Identify given statements pertaining to the types of termites as true or false.

Types of Termites. There are many species of termites in the world. For practical purposes, those in the United States are commonly divided into two major groups: subterranean and nonsubterranean. Termites receive their common names from the location of their colonies or nests and from their feeding habits. Subterranean termites *(Retienlitermes)* often work in wood above ground, but must have direct communication by means of their tunnels with the underground colony.

The nonsubterranean termites *(Kalotermes)* colonize above ground. Although they have the common habit of feeding on the cellulose usually derived from wood or wood products, their life cycles and methods of attack, and consequently their methods of control, are quite different. Depending on these factors, the nonsubterranean termites may be of the powderpost, dry-wood, damp-wood, or rotten-wood varieties.

Exercises (A15):

Indicate whether the statements below are true (T) or false (F).

___ 1. The common names for termites are determined solely from the location of their colonies.

___ 2. Although subterranean termites often work in wood above ground, they must have channels to the underground colony.

___ 3. Nonsubterranean termites often work in wood below the ground surface.

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___ 4. The major group of termites that is subdivided into dry-wood, damp-wood, or rotten-wood varieties is the subterranean group.

A16. Discriminate between the features of termites and ants.

General Description of Termites. Termites are commonly but erroneously called white ants. However, not all species and castes of termites are white, and no termite is a true ant. Termites are about ant size. You can tell the flying reproductives from ants by two distinguishing characteristics: the wings and the body shape. The termite has four wings of approximately equal length and about twice as long as the body. The ant's wings are only a little longer than the body, and the second pair is much shorter than the first. The ant is typically wasp waisted, having the abdomen connected tod the thorax by a thin petiole, while the "slab-sided" termite is not pinched in at the waist.

Exercises (A16):

1. The flying reproductive termites can be readily distinguished from ants by the ________________ and the ______________ ______________ .
2. The first and second pairs of wings of termites are ________________ ________________ in length; whereas the first pair of wings of ants are ________ than the second pair.
3. The body of an ant is typically ________________ waisted, while the body of the termite is "________ ____________ ."
4. Termites are often erroneously referred to as "________________ ________________ ."

A17. Given statements that pertain to termite caste systems, colony development, and life requirements, identify the type of termite to which each statement applies.

Colony Development and Caste Systems. Although both major divisions of termites have a caste system to some extent, the subterranean group is most common and is also the most complex.

Nonsubterranean. Since dry-wood termites *(Kalotermes)* are the most common group of the nonsubterranean termites within the United States, the nonsubterranean group will be discussed as dry-wood termites throughout the remaining portions of this text.

Colony development follows definite, predictable patterns for various species in various climatic areas. The presence of termites is most often noticed by building occupants during or shortly after an emergence of the sexually mature, winged reproductives. After the emergence and the pairing of male and female reproductives, the swarm is rapidly dissipated as individual pairs leave to establish new colonies. The dry-wood termites will normally seek the shelter of cracks and crevices in sound, dry wood above the ground when establishing new colonies. The subterranean termites establish their new colonies in the soil near wood.

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In area of temperate climate, a colony develops slowly. A relatively new colony of dry-wood termites consists of only the original reproductives and no more than six nymphs. At the end of 2 years, the young colony may consist of the original reproductives, 1 soldier, and 12 or more nymphs. Old colonies have fewer than 3,000 individuals, and winged reproductives capable of establishing new colonies are never found in colonies less than 4 years old. No worker caste is found in *Kalotermes* colonies.

Subterranean. These termites have four castes: the workers, soldiers, secondary reproductives, and the primary reproductives.

The workers (fig. 2-1) are responsible for many functions of the colony. They feed and care for the other members of the colony who are not capable of feeding themselves. Workers attack the wood and digest the cellulose by means of the protozoan that is contained in their stomachs. The workers are the first eggs hatched in a colony; therefore, they are responsible for increasing the size of the colony, and as the workers grow in the colony, the colony itself grows. The workers care for, feed, and groom the queen, the eggs, and the soldiers.

The only function of the soldiers is to protect the colony. Their head and thorax are modified for the protection of the colony (fig. 2-1). Their main concern is the ant, a vicious natural predator.

The secondary reproductives are wingless (fig. 2-1) and are the most important source of eggs for the colony. They may get a group of males and workers together and set about building another colony close to the original without any above-the-ground warning.

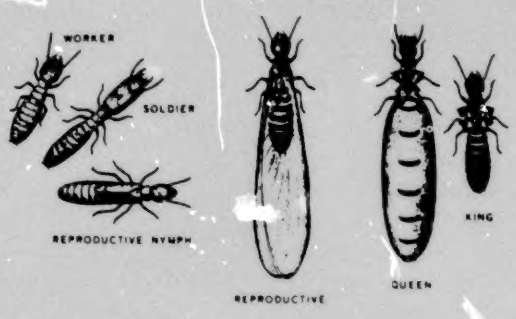

Figure 2-1. The termite.

The primary reproductives are the winged swarmers (fig. 2-1). These adults have dark pigmentation and two pairs of equal length wings. Males and females pair off in the swarm and then attempt to establish a cell, where mating occurs. When the eggs hatch, the new colony has its start.

A relatively new colony of subterranean termites will normally consist of the original pair of reproductives, a few dwarf workers, and one dwarf soldier. During the second year, the young reproductives may be found. A full 2 years is required for the complete development of the reproductives. In older colonies, supplementary reproductives may assist in colony development, and thousands of eggs and a quarter of a million termites may be found. In the colonies of subterranean termites, the worker caste predominates. The workers are small, cream colored, soft bodied, and sexless. The soldiers have large heads with specialized mouth parts and are normally incapable of feeding themselves. The nymphs are immature termites, often immature reproductives. They may be observed to have "wing pads" which, upon the maturity, develop into wings.

During periods of favorable weather, mature colonies may produce new swarms of dark-bodied, winged reproductives. The time of emergence will depend upon geographic area, climatic conditions, the species of termite involved, and other factors such as the heating of the building infested. In temperate areas, the emergence of termites may be expected in the spring, and depending on species, also at odd times during the summer and fall. If the emergence occurs within a building, the flying termites may constitute a considerable nuisance. As the reproductives may be emerging as rapidly as the limiting size of the openings permit, the existence of residual insecticides in the area or the use of contact insecticides as sprays or mists will be of little value. Injecting contact insecticides into the emergence openings can provide a measure of relief, but if nothing is done, the emergence will last for only a few hours.

Termite Life Requirements. Termites have specialized food requirements which make them destructive, moisture requirements which make them vulnerable to control by soil poisoning, and requirements for protection which can make their early detection difficult.

Food. Termites characteristically live on wood and other cellulose materials. Depending on the type of termite involved, the wood may or may not serve as the nesting site, but it always serves as a source of food. The food that the termites ingest in small pieces is not digested directly by the termites, but by microscopically small protozoa living within the termites' digestive tract. The termites utilize the byproducts of the protozoan metabolism for their own nourishment.

Moisture. Termites, like most other forms of animal life, contain considerably large quantities of water in their body tissues. Because they are typically soft-bodied and delicate insects, termites must be protected against excessive drying. The dry-wood termites seal their nests and tunnels tightly during periods of low atmospheric humidity. Despite this habit, they are normally limited in their distribution to regions of high humidity. The subterranean termite constructs its own air-conditioning system by maintaining its nest in the moist soil and connecting the nest and the feeding galleries with airtight tunnels. Despite their air-conditioning, subterranean termites must normally return to the moist soil several times each day, a fact that makes them particularly vulnerable to control at or below the ground line. In extremely wet soil conditions, subterranean termites may construct "subnests" above the ground.

Protection. Termites have several natural enemies, the most serious of which are probably the ants that can easily enter the termite tunnels in search of food. The ability of some termite species to plug up their galleries almost as rapidly as they are invaded provides some degree of protection against ants. The greatest deterrent to sustained attack by ants is the ability of the soldier termites to plug up the tunnels with their heads or to defend them with rather formidable jaws. The soldiers of some tropical species are equipped to wage a form of defensive "chemical warfare."

Exercises (A17):

Match the statement in column A with the type termite in column B.

Column A

___ 1. A caste system exists among these termites.
___ 2. A soldier caste exists among these termites.
___ 3. These termites may nest above ground.
___ 4. The worker caste predominates in this group.
___ 5. These termites require moisture in order to survive.
___ 6. The only function of the soldier is to protect the colony.
___ 7. The secondary reproductives are wingless and the most important source of eggs for the colony.
___ 8. The primary reproductives are winged swarmers.
___ 9. These termites seek the shelter of cracks and crevices in sound wood above the ground.
___ 10. These termites must normally return to the moist soil several times each day.

Column B

a. Subterranean termites.
b. Dry-wood termites.
c. Subterranean and dry-wood termites.

A18. Identify given statements concerning the recognition of termite damage as true or false.

Termite damage to buildings follows predictable patterns. If permitted to continue, the damage can become extensive. Since facility inspection is of primary importance in the control of termites, you must be able to recognize damage caused by termites.

Damage Pattern. Depending upon the design and building materials used, the quality of workmanship, and certain environmental factors, a given structure will be subject to attack by a given species of termites in a particular manner. Termite attacks in several similar buildings are so similar that you can find a predictable pattern.

In their blind probing for new sources of food, subterranean termites construct exploratory tunnels through the soil. These tunnels emerge above the ground level and are then usually cemented securely to solid objects, such as foundation walls and piers or pipes. These tunnels of earth and other materials can continue upward, when protected, until the termites find food. They often reach heights of several feet. If solid objects block their path, the termites will continue probing until they have found or created a passage. They can penetrate expansion joint fillers. They can also use natural cracks in foundation walls. Because the spaces between bricks or building blocks are rarely completely filled, termites may use these areas. Hollow tile foundations can provide a nearly perfect approach to structural wood, as the termite tubes are well protected and are not detected during inspections.

Once gaining entry to the wood of a building, the termites may carry on their destruction of several years before they are found. The use of termite shields will, if the shields are properly installed and maintained, force the termites to extend their tubes out over the surface of the shields and thus will facilitate inspections. In buildings comprised primarily of concrete and masonry, damage may be limited to such wooden items as doors and window frames, baseboards, and insulating material composed of wood fibers. In masonry and concrete buildings with wooden floors, damage may be most severe below the floor level. In frame buildings with solid concrete decks, the damage may be evident first in door or window frames or baseboards, but more extensive hidden damage to studs, sheathing, and sole plates may exist. In wooden frame buildings, the pattern varies, depending on the type of construction and environmental factors, but the damage may include all of these types.

Extended Damage. Though it is unusual, a new building can be damaged severely during its first few years. This will happen when wood debris, usually tree stumps and roots, containing large, active colonies is left in the soil at the building site. Under such conditions, the extended pattern of damage is the same as that found in older buildings with well-established colonies. The emergence of termites at a point much above the first floor level in a frame structure would normally indicate a large colony and considerable damage. An emergence of subterranean termites may occur in the attic of a two-story building. Subterranean termite tubes have been found at an elevation 32 feet above the ground level in a military building.

Inspection. All structures built wholly or in part of wood should be inspected at least annually for active termite infestations, regardless of preventive measures employed in construction. Attention must also be given to those conditions conducive to future termite attack. Under some conditions, inspections should be made semiannually rather than annually. The subterranean nests of termite colonies or points of entry into buildings can often be located quickly if the emergence is observed. For this reason, pest control supervisors should give prompt attention to all complaints, such as those concerning "flying ants," which could indicate a termite emergence. All information available at the time the complaint is answered should be recorded on the form used for recording the scheduled annual/semiannual inspections. The purpose of the annual/semiannual inspection includes the on-the-site planning of control procedures as well as the detection of active or potential infestations. Thus, the inspections of structures should be made by personnel trained in the selection and application of the proper control techniques as well as in the determination of the need for control. All termite inspections and treatments must be recorded on the DD Form 1070, Termite and Wood Decay Inspection.

Exercises (A18):

1. Place the letter "T" before the true statements.

___ a. Termite attacks in similar buildings are not usually so similar that a predictable pattern may be found.

___ b. subterranean termites will build tubes of earth up the foundation walls.

___ c. In buildings made primarily of concrete and masonry, damage may be limited to wood doors and window frames.

___ d. In concrete and masonry buildings with wooden floors, the damage may be very severe above the floor level.

___ e. In frame buildings built on concrete slabs, the damage may be evident first in door or window frames or baseboards.

___ f. The emergence of termites at a point much above the first floor level in a frame structure would indicate a large colony and considerable damage.

___ g. All termite inspections and treatments must be recorded on DD Form 1070.

___ h. Pest control supervisors should not give prompt attention to all complaints.

2. Correct all incorrect statements.

A19. Complete given statements concerning measures that may be taken to prevent and correct termite problems.

An effective and economically managed program of termite control will always include the three principal phases of inspection, preventive control, and such corrective control as may be required. The techniques used include the elimination of food through the proper design and construction and through the application of sanitation at the building sites; the control of moisture through adequate drainage and ventilation; the exposure of termite tubes through the use of impenetrable barriers between the soil and the structural wood; and the use of chemicals for direct poisoning, for the creation of barriers by soil poisoning, and for the preservative treatment of wood.

Preventive Control. The best time to provide protection from subterranean termites is during the planning and construction of a building. Many common design and construction practices are favorable for infestation. Some preventive control measures can be applied after construction and during the use of the buildings.

Construction. Military buildings should be planned and constructed to provide protection against termites. Recommendations regarding design and construction and the use of wood preservatives should be followed without deviation regardless of the urgency to complete construction by a specified date. Some common errors of design and construction are burial of stumps, logs, boards, stakes, form lumber, and wood scraps beneath buildings or next to the foundations; improper grading and drainage; insufficient air circulation and cross-ventilation; failure to use chemically preserved wood.

Site sanitation. All surplus wood, including stumps, tree roots, logs and other wood debris, should be removed from the building site before construction work is started. All form lumber, grade stakes, and wood scraps should be removed by the time construction work has been completed.

Foundation construction. It is important that building foundations be impervious to subterranean termites and that woodwork resting on the foundation be protected against attack. Foundation types may be rated by their relative resistance to penetration as follows:

a. Poured concrete, reinforced to prevent cracks, with the expansion joints properly filled.

b. Masonry walls capped with a minimum of 4 inches of reinforced concrete or its equivalent.

c. Hollow blocks with all of the top rows and joints between blocks filled with concrete.

d. Wood posts, piers, steps, or braces pressure treated with an approved chemical preservative and capped, when recommended, with metal termite shields to prevent the insects from gaining hidden access to the buildings or other structures.

Ventilation and drainage. It is necessary to provide adequate ventilation and drainage to prevent termite attack. The number and size of openings should be determined by the soil moisture, air movements, and humidity. Areas beneath buildings should be well drained. The soil adjacent to foundation walls should be graded to permit the drainage of surface water away from the buildings.

Clearance beneath buildings. In order that periodic inspections can be made for subterranean termites, adequate crawl space should be provided beneath buildings. The minimum clearance for effective inspection is 18 inches from ground to bottom of lowest joist, beam, or girder.

Skirting. When skirting is used, a clearance of [illegible] inches between it and the ground is needed. If this space is closed in winter, it should be reestablished early each spring.

Miscellaneous appendages. All miscellaneous building appendages, including porches, steps, terraces, platforms, and fire escape ladders, should be installed with an unbridged clearance or effective barrier so as to prevent entry of termites into buildings. All wood used in contact with the soil should be pressure treated with approved wood preservatives. Only treated wood should be used for construction timbers placed on concrete or masonry foundations. Pipes and conduits often provide entrance points for termites. Plumbing, electrical conduits, and other piping should be installed clear of the ground and should not be supported by wood braces or other appendages that touch the ground. At the point where piping enters the floor of wall from below ground, a funnel type of shield caulked with a coal-tar type of mastic provides an effective barrier.

Chemical soil barriers. Residual insecticides may be added to the soil. When properly applied, they will provide long-lasting barriers of poisoned soil adjacent to foundation walls and piers and under concrete slabs. The formulations and application rates provided in Appendix A in the supplement represent the minimum found to provide effective control for native North American species for long test periods. Any variation in rate of application, materials, or concentrations should be as recommended by the command entomologist or pesticide label. Water emulsions are normally used. Oil solutions may be used when recommended by appropriate technical authority. Oil solutions should not be used against surfaces that have been waterproofed or dampproofed with asphaltic or other materials subject to deterioration by oil. Oil may "burn" the roots of ornamental plants. Oil for solutions should not be heavier than No. 2 fuel oil.

Wood preservatives. Lumber and other forest products that are exposed to excessive moisture, fungi, and wood destroying insects such as termites should be treated with wood preservatives to prolong their useful life. The type of treatment and the preservatives to be applied depend upon the type and severity of exposure and upon the desired life of the material treated. Surface treatments as well as dip or soak treatments, which provide shallow penetration, protect wood against dry-wood termites. However, the deeper penetration provided by pressure treatment is required for protection against subterranean termites. Only the wood actually treated is protected. Termites will "bridge over" treated wood with their shelter tubes just as they will bypass other nonedible structural materials.

Screening. As a deterrent to attack by dry-wood termites, 18 x 18 mesh, noncorrodible screening may be used to cover all points of entry such as windows, doorways, ventilators, and other openings. Particular attention should be given to screening louvers, eaves, or apron ventings, and field strips supporting tile.

Exterior surfaces. Further prevention of attack by dry-wood termites can be obtained by maintaining smooth exterior surfaces on buildings. All exterior cracks, grooves, and joints should be well filled before painting. A good coat of paint, with careful application at points of vulnerability, will aid in warding off attack.

Corrective Control. The corrective control of termites involves the same basic principles as does preventive control and many of the same procedures are used. However, because in this case the control is applied to existing structures, some different techniques are used for the application of chemicals. Though insecticides applied to soils may kill out existing colonies, the creation of a barrier of impenetrable soil is still the aim of soil poisoning. But because of the combination of certain types of structures and soils and the labor costs involved, limited "spot treatment" of the most vulnerable areas may be justified in some cases. Because of the great variations in soil types and in termite species, such limited spot treatment should be considered only if recommended by the command entomologist.

Soil beneath a concrete slab may be treated either from above the slab or from outside the building. In the *pressure treating* method, holes are drilled through the slab on 12- to 18-inch centers 6 to 8 inches from cracks and expansion joints. The insecticide is pumped through these holes to provide quick, even distribution. A plumber's test plug or similar device with an expandable rubber ring is used to seal the hole and prevent back flow of the emulsion under pressure.

Using the *rodding* method, holes are drilled through the foundation wall beneath the slab, and a long perforated pipe, pointed at the end, is driven between the slab and the soil. The insecticide is then pumped through the rod, under pressure, as the rod is withdrawn.

Control of existing colonies of dry-wood termites by means other than removal of the infested wood requires the application of toxic chemicals to the termites in the wood. The application methods include injection of dust, injection of liquids, surface application of penetrating chemicals, and fumigation.

a. Dusting. Insecticidal dusts may be blown into holes punched or drilled into the termite gallery. Only very small quantities are needed.

b. Squirting. Insecticidal liquids may be squirted through holes into the termite nests. Oil formulations which will stain or prevent later painting should be avoided.

c. Surface treatment. If no paint film is present to block penetration, surface treatment can be effective. Grease or emulsion formulations of pentachlorophenol will penetrate satisfactorily, but may prevent later painting. Trichlorobenzene will penetrate deeply and has a fumigating effect. It can be fortified with insecticides (see Appendix A of Supplement of Volumes 4, 5, 6, and 7).

d. Fumigation. Structural fumigation with methyl bromide will kill all dry-wood termites in the structure. However, it is expensive and hazardous, and provides no residual effect to prevent future infestations.

Exercises (A19):

1. The three principal phases of termite control include ____________________, ____________________, and ______________.
2. The best time to provide protection from subterranean termites is during the ______________ and ______________ of a building.
3. Some common errors of design and construction are burial of ______________, ______________, ______________, ______________, ______________, ______________, and ______________ beneath buildings or near foundations; improper ______________ and ______________; insufficient ______________ and cross-ventilation; failure to use ______________ preserved wood.
4. Before a building is constructed, the soil adjacent to the foundation walls and piers and under concrete slabs must be treated with a ______________ ______________ to provide a long-lasting barrier.
5. During the construction stage, the lumber or other forest products which are exposed to excessive moisture, fungi, and wood-destroying insects should be treated with a ______________ ______________ to prolong their useful life.
6. On exterior surfaces, a good ______________ of ______________ will aid in warding off attacks from termites.
7. Soil beneath a concrete slab may be treated from ______________ the slabs and from ______________ the building.
8. The four methods of applying toxic chemicals for the control of termites are ______________, ______________, ______________, and ______________.
9. For a surface treatment for control of termites, the insecticide which will penetrate deeply and have a fumigating effect is ______________.
10. Structure fumigation with ______________ will kill all dry-wood termites in the structure; however, it is hazardous and provides no residual effect.

2-3. Wood-Boring Insects

Wood-boring insects are separated into three groups: the powder post beetles, the powder post borers, and the carpenter ants and bees. This section covers the characteristics (descriptions, habits, and habitats) of these insects as well as the controls for them.

A20. Discriminate among the general characteristics of three powder post beetle families.

Powder Post Beetles. Powder post beetles are so named because of the powdery substance (frass) that appears in areas where these beetles are working. This powdery substance may be observed on wood surfaces or in piles on the floor near chair and table legs.

The powder post beetles are separated into three families: Lyctidae, Anobiidae, and Bostrychidae. Powder post beetles belong to the order Coleoptera. The larvae are responsible for most damages. They are the second most important insect pest of wood articles and timbers.

Lyctidae. This family is the true powder post beetle. The larvae are whitish with dark brown heads and mandibles. The anterior portion of their bodies is larger than the posterior portion. The larvae have three minute pairs of legs. The last pair of spiracles are much larger than the other. The very young larvae bore into the wood source. Once they mature, they bore almost completely out in order to pupate.

Once pupation is complete, the adults bore completely out, pushing a fine powdery wood dust out of the wood as they emerge. The adults are reddish brown to black and are from 2.4 to 5.6 mm long. The antennae of these beetles terminate in a two-segmented club. The tibiae bear spurs. The basal abdominal segment is as long as the second and third segments combined.

True powder post beetles only attack seasoned wood and will not attack a live tree or freshly cut wood. The adults will usually deposit eggs into the surface pores of lumber while it is being stored and while it is curing. After development is complete, which may take 3 months to a year, the adults will emerge from finished wood and furniture products.

These beetles prefer the sapwood of hardwoods such as oak, hickory, and ash, and are commonly found in tool handles, pallets, furniture, picture frames, and in interior woodwork of buildings.

The exit holes, which run parallel with the wood grain, are filled with frass (absent of fecal pellets) and are approximately 1.2 mm in diameter.

Anobiidae. The larvae of this family attack the sapwood of hardwoods and softwoods, such as pine, oak, beech, alder, and willow. Anobiidae larvae prefer old wood and are commonly found in girders, beams, foundation timbers, and antique furniture.

The larvae are described as being whitish, slightly curved, wrinkled, and having tiny hairs on the body. They have three pairs of short legs and toothed mandibles. They range in size from 6.3 to 12.5 mm long.

When young, the larvae bore into the wood, where they may live for a year or two. Just before they pupate, they bore toward the surface, but not completely out.

When the adults, emerge, they leave small holes which average 2.4 mm in diameter. The tunnels or galleries may run across the wood grain and are loosely filled with frass containing distinct elongate or bun-shaped fecal pellets. These adults are reddish to blackish brown and are usually less than 8 mm long. The thoracic region is usually margined at the sides, and the head is barely visible from a dorsal view. They do not have spurs on the tibiae. They deposit eggs in cracks and crevices of old wood or in the mouth of an old exit hole.

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Bostrychidae. This family of powder post beetles is commonly referred to as the false powder post beetle. There are two species that are most commonly encountered: the bamboo borer and the lead-cable borer.

a. Bamboo borer. This bostrychid in the adult stage is brown, cylindrical, and 3 to 4 mm long. As the common name implies, it prefers bamboo woods and will often be found in furniture, ornaments, and poles constructed from bamboo.

b. Lead-cable borer. The lead-cable borer is also known as the short-circuit beetle, because it actually causes shorts in telephone and other electrical circuits while feeding upon its preferred food source (lead) which is found in underground cables. This beetle is also often found in wine casks. The adults are reddish brown, cylindrical, and 5 to 6 mm long.

Bostrychidae larvae are whitish, curved, wrinkled, and robust. They have small heads and greatly enlarged thoracic regions that bear three pairs of well-developed legs. Their mandibles are not toothed. Larval tunnels generally run parallel with the wood grain and are tightly packed with frass.

The adults bore into the wood to deposit their eggs and may at times insert the eggs into the cells of the wood. Once the eggs hatch, the larvae bore toward the surface and pupate. After pupation, the new adults emerge from the wood. The adults have an enlarged, roughened thorax that gives the beetle a hump-backed appearance. They have spurred tibiaes.

The entrance and exit holes of these beetles average 6.3 mm in diameter.

Exercises (A20):

Match the description in column A with the type beetle in column B.

Column A	*Column B*
___ 1. The very young larvae bore into the wood source, and once mature, they bore almost completely out to pupate.	a. Lyctidae.
___ 2. The emerging adults leave small holes which average 2.4 mm in diameter.	b. Anobiidae.
___ 3. The adult bores into the wood to deposit eggs and may at times insert eggs into the cells of the wood.	c. Bostrychidae.

Column A

___ 4. The adults have a roughened thorax that is enlarged, giving the beetle a hump-backed appearance, and they have spurred tibiaes.
___ 5. The tunnels or galleries may run across the wood grain and are loosely filled with frass containing distinct, elongated or bun-shaped fecal pellets.
___ 6. A true powderpost beetle.
___ 7. False powder post beetle.
___ 8. The larvae attack the sapwood of hardwoods and softwoods.
___ 9. These adults are reddish to blackish brown in color and are less than 8 mm long.
___ 10. The larvae have three minute pairs of legs, and the last pair of spiracles are much larger than the others.
___ 11. The antennae terminates in a two-segmented club, and the tibiae bear spurs.
___ 12. The larvae have three pairs of short legs and tooth mandibles.
___ 13. The larvae are whitish, slightly curved, wrinkled, and have tiny hairs on the body.
___ 14. The larvae have small heads and greatly enlarged thoracic regions that bear three pairs of well developed legs.
___ 15. The larvae prefer old wood and are commonly found in girders, beams, and foundation timber.
___ 16. The larvae are whitish with dark brown heads and mandibles.
___ 17. The basal abdominal segments are as long as the second and third segment combined.
___ 18. The adult's thoracic region is usually margined at the sides and the head is barely visible from a dorsal view. They don't have spurs on the tibiae.
___ 19. Adults are reddish brown to black and are from 2.4 to 5.6 mm long.
___ 20. Larval tunnels generally run parallel with the wood grain and are tightly packed with frass.
___ 21. The larvae anterior portion of the body is larger than the posterior portion.
___ 22. Their mandibles are not toothed.
___ 23. Only attack seasoned wood; will not attack a live tree.
___ 24. The larvae range in size from 6.3 to 12.5 mm long.
___ 25. Prefer the sapwoods of hardwoods, such as oak, hickory, and ash.
___ 26. The larvae may live in the wood for a year or two before boring towards the surface.
___ 27. Exit holes run parallel with the wood grain, are filled with frass, and are 1.2 mm in diameter.
___ 28. The larvae are whitish, curved, wrinkled and robust.

A21. Identify the family of powder post borers to which given statements apply.

Powder Post Borers. Powder post borers belong to the order Coleoptera and are separated with two families, Cerambycidae and Buprestidae. These beetles are primarily feeders on dry woods. Under natural forest conditions, they play an important role in the reduction of dead trees to permit new growth. Their destructiveness in structural woods, however, can result in considerable economic losses.

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Cerambycidae. This family of beetles is often referred to as long-horned wood borers or roundheaded wood borers. It contains some of the largest species of wood borers. Cerambycids will attack living or dead wood; therefore, they are generally considered to be pests of ornamental plants, such as shade trees and fruit trees. However, the *old house borer* is one species that is very important as a structural pest. It attacks sapwood of softwoods, such as pine and spruce, and is commonly found in floor joists, sills, beams, studs, and subflooring.

The old house borer deposits eggs in tight crevices, such as cracks and natural checks in boards. Upon hatching, the larvae bore into the wood. They may stay in this stage for 2 to 3 years. The tunnels excavated are round because the head and thoracic region of the larvae are round. These tunnels are loosely filled with frass. Before the larvae pupate, they bore toward the surface. Following pupation, the adults emerge at the surface and leave oval holes.

The old house borer larvae are flesh colored, straight bodied, wedge shaped, and may be up to 25.6 mm long. The adults are brownish black in color and have many gray hairs on the head and anterior portion of the body. Each wing cover has two patches of gray, and, when fused, they will form either two transverse bands or two downy white spots.

Buprestidae. This family of wood borers is often referred to as flatheaded wood borers because of the enlargement of the thorax immediately behind the relatively small head. Like the family Cerambycidae, the buprestids attack living and dead wood and are considered to be more important as pests of ornamental plants than as structural pests.

Buprestids are attracted to smoke. This attraction leads them to forest fires, where they deposit eggs in bark cavities of scorched trees. Once the eggs hatch, the elongate, whitish, legless larvae bore into the sapwood and leave tunnels that are tightly packed with frass.

The adults can usually be recognized by their bright metallic colors. Because there are many species of buprestids, the coloration and size of these beetles vary. Most are iridescent blues and bronzes. These beetles range in size from small to medium and may be either flat bodied or cylindrical.

Exercises (A21):

Match the statement in column A with the family of powder post borers in column B.

Column A

___ 1. Primary feeders on dry wood.
___ 2. Will attack living or dead wood.
___ 3. Pests of ornamental plants, such as shade trees and fruit trees.
___ 4. Long horned wood borers or roundheaded wood borers.
___ 5. Flatheated wood borers.
___ 6. Destructiveness in structural woods can result in considerable economic loss.
___ 7. Old house borers attack sapwoods of soft woods and are commonly found in floor joists, subflooring, sills, beams, and studs.
___ 8. Adults have bright metallic colors; most are iridescent blues and bronzes.
___ 9. The adults are brownish black and have many gray hairs on the anterior portion of the body.
___ 10. The tunnels excavated are round because the head and thorax region of the larvae are round.

Column B

a. Cerambycidae.
b. Buprestidae.
c. Both.

A22. Identify statements pertaining to the preventive and corrective measures for the control of powder post beetles and borers as true or false; correct any false statements.

Control of Powder Post Beetles and Borers. Powder post beetles and borers can be controlled effectively by implementing preventive and corrective measures.

Preventive control. Wood susceptible to powder post beetle attack and intended for prolonged or indefinite storage may be protected economically by a preventive treatment. Oil solutions containing chlorinated hydrocarbons, applied as 3-minute dips, have proven effective in preventing beetle attack for 10 years or more after treatment. Emulsions and suspensions are less effective than oil solutions. Satisfactory solutions may be prepared from fuel oil, trichlorobenzene, or other recommended solvents. An effective general-purpose protective dipping solution should contain 5 percent pentachlorophenol, approximately 5 percent of a water repellent, one of the approved chlorinated hydrocarbons, and a penetrating solvent. The pentachlorophenol will prevent fungus damage, and the chlorinated hydrocarbons will prevent insect attack. When wood so treated is cut or refinished, the cut surfaces should be covered with preservatives by dipping or brushing. An excellent wood preservative, without the insecticide, is pentachlorophenol. The pentachlorophenol is not needed unless the wood is to be stored or used where it would get wet and be subjected to attack by decay. For such wood not subject to decay, an oil solution containing one of the recommended insecticide solutions will be adequate to protect it from beetle attack. Tool handles, gun stocks, and other items may be protected against lyctus attack if all surfaces are coated with a heavy linseed oil or paint which fills the wood pores and prevents oviposition (depositing of eggs).

Corrective control. Active infestations can be controlled with 3-minute dip treatments in oil solutions of the chlorinated hydrocarbons. Thorough brush and spray applications are effective on small-dimension stock, such as tool handles. For control in buildings, good penetration of the insecticide is important. Paint, varnish, or enamel should be removed before the insecticide is applied. In the treatment of laid flooring in buildings, deeper penetration is generally attained by thoroughly brushing the oil solution into existing beetle emergence holes and the crevices between the boards. Merely spraying the oil solution onto the exposed surface of the flooring frequently does not give sufficient penetration to give satisfactory control. In heavy-dimension stock, two or more applications may be required. For heavy timbers, vat dipping or drilling and injection of the oil solution under pressure may be necessary. Fumigation with methyl bromide in vacuum chambers is effective, but it provides no residual protection.

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exercises (A22):

1. Place the letter "T" before the correct statements.

___ a. Oil solutions containing chlorinated hydrocarbons, applied as 3-minute dips, have proven effective in preventing beetle attack for 10 years or more after treatment.
___ b. Emulsions and suspensions are more effective than oil solutions.
___ c. An effective general-purpose protective dipping solution should contain 5 percent pentachlorophenol, approximately 5 percent of a water repellent, one of the approved chlorinated hydrocarbons, and a penetrating solvent.
___ d. The pentachlorophenol will prevent insect attack, and the chlorinated hydrocarbons will prevent fungus damage.
___ e. Active infestations can be controlled with a 3-minute dip treatment in oil solutions of the chlorinated hydrocarbons.
___ f. Paint, varnish or enamel can be left in place when the insecticide is applied.
___ g. Spraying the oil solution onto the exposed surface of the flooring frequently does not give sufficient penetration to give satisfactory control.

2. Correct any false statements.

A23. Complete given statements concerning the characteristics and controls of carpenter ants and bees.

Carpenter Ants and Bees. These insects belong to the order Hymenoptera. Even though they are venomous, they have been reserved for this section because they are more important as structural pests.

Carpenter Ants. Carpenter ants are so named because they tunnel into wood and excavate to provide the galleries that form a home for the colony. Although they are general feeders and will not eat the wood, they can sometimes do serious damage. Common black carpenter ants are large ants, sometimes 12.5 mm long. They build their nests in a variety of places, such as the dead heartwood of living trees, logs, house timbers, poles, and almost any wood material. They are most destructive in soft woods. Most of their tunnels are approximately parallel and run lengthwise with the grain of the wood. Other shorter tunnels that cut across the grain connect the longer parallel tunnels within the wood and open to the outside. Where wood is seriously damaged by carpenter ants, it should be replaced. For the most satisfactory control, short of removal of the infested wood, the nest must be located. Insecticidal formulations containing chlorinated hydrocarbons are effective if injected into the nests. In some cases, it is difficult to find the nest, but the ants may be seen coming from cracks or joints in the building. In such cases, good control can often be obtained by the use of insecticidal dusts that are carried to the nest by ants walking through them, or by the use of poisoned baits.

Carpenter bees. Carpenter bees belonging to genus *Xylocopa* are large bees, sometimes an inch long. The majority of these bees are found in the southern portion of the United States and in the Tropics. Carpenter bees, like carpenter ants, do not eat wood but excavate tunnels for nesting sites. Unlike ants and some other bees, carpenter bees are not social insects developing large colonies. Tunnel openings are usually perfectly round, or nearly so. The tunnels, which may extend as much as a foot, are divided into brood cells. The occasional tunneling of structural timbers by carpenter bees should cause no alarm to building occupants; however, repeated attacks in the same area may result in significant damage. Dusting partly completed tunnels with insecticide powder will kill the adult bees. Insecticides may be used as preventive sprays or may be packed into the tunnels, which are then sealed with putty. The most effective preventive treatment for use in structures in a heavy protective coating of paint.

Exercises (A23):

1. Carpenter ants are so named because they ______ ______ into wood and ______ to provide the galleries that form a home for the colony.
2. Carpenter ants are most destructive in ______ woods.
3. Insecticidal formulations containing ______ ______ hydrocarbons are effective if ______ into the nests.
4. Good control can be often obtained by the use of insecticidal ______ that are ______ into the nests by ants walking through them.
5. The majority of carpenter bees are found in the ______ portion of the United States.
6. Carpenter bees do not ______ wood but ______ ______ tunnels for nesting sites.
7. Partly completed ______ can be ______ with insecticide ______ to kill the adult bees.
8. The most effective preventive treatment for use in structures is a heavy protective ______ of ______ .

CHAPTER 3

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Ornamental and Turf Pests

ORNAMENTALS (trees and shrubs) represent an important part of the wealth and beauty of this country. They make up our forests and beautify residential grounds, city streets, highways, and the countryside in general. On many of our military installations, cultivated plantings and forest areas are the most attractive features. In addition, they provide protection against dust, erosion, and flooding.

Trees and shrubs on military installations may be attacked and progressively damaged by insects and other pests in many ways. For example, a colony of caterpillars may strip the foliage from twigs and branches; aphids may suck the sap from new shoots and leaves, causing them to wilt or to grow abnormally; tiny scale may encrust branches and twigs, withdrawing enough food to kill plants outright; and borers of many kinds may invade the bark and wood, seriously injuring or killing plants. More subtle and often more serious is the damage caused by those insects that carry bacterial, fungal, or viral disease.

Turf is subject to attack from insects and insectlike pests that cause it to turn brown and die. The extensively grassed areas at military installations represent important investments in land management (dust and erosion control) and in the morale benefits of lawns, golf courses, and recreation areas. The many pests which destroy lawns and other grassed areas are grouped by the methods of attack and types of damage. Some live in the sod and chew the grass roots. Others live above ground and chew the leaves and stems. Still others suck the juice from the plants.

3-1. Ornamental Pests

Ornamental pests, as discussed in this section, are identified as those insects that feed on trees and shrubs by eating entire leaves, eating portions of leaves, and boring into the bark and sucking the sap from leaves and stems. Other insects included in this group are the gall-forming insects.

This section covers the characteristics and controls for (1) common lepidoptera defoliators, (2) webbing lepidoptera defoliators, (3) miscellaneous lepidoptera defoliators, (4) skeletonizing defoliators, (5) mining defoliators, (6) bark beetles and engravers, (7) sapsuckers, and (8) gall formers.

A24. Associate three common Lepidoptera defoliators with their descriptions.

Common Lepidoptera Defoliators. Many of the insects that defoliate shade trees and shrubs are general feeders that attack a wide variety of hosts. The more important and abundant ones are typical caterpillars, such as the fall cankerworm, white-marked tussock moth, and gypsy moth.

Fall cankerworm. The fall cankerworm is found in nearly all parts of the northern United States and as far west as Montana and south to the Carolinas and Missouri. It has been reported in Colorado and California.

The adult male has a wing spread of approximately 31 mm. The wings are light gray with pale markings. The female is light gray and wingless.

Eggs are deposited in clusters on twigs in late fall and hatch in the spring. Pupation occurs in a silken cocoon in the ground just a few inches below the surface.

White-marked tussock moth. This moth is found along the entire Atlantic coast and westward to Colorado. It feeds chiefly upon shade trees, such as sycamores.

The adult has a wing spread of about 25 mm. The wings are gray with wavy dark bands and pale markings. The female is robust, light gray in color, and is wingless.

Eggs are deposited in the fall on silken cocoons in which pupation occurs. They are covered with a white liquid substance that becomes hardened to form a crust which makes them very noticeable against the bark of trees. These eggs hatch in early spring and the larvae begin to feed immediately.

The larvae are approximately 3.8 cm long. They have a bright red head and two raised red humps on top near the posterior end.

Gypsy moth. The gypsy moth is found primarily in the New England States and parts of New York and Pennsylvania. It feeds mainly upon such trees as apple, alder, birch, oak, and willow.

The adult male has a wing spread of about 3.8 cm. These wings are brown with yellowish markings. The wings of the female are almost entirely white with a few

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dark markings and are approximately 5 cm across. The female has a thick heavy body and does not fly.

Exercises (A24):
Match the statements in column B with the pests in column A.

Column A	*Column B*
____ 1. Fall cankerworm.	a. It feeds mainly upon such trees as apple, alder, birch, oak, and willow. The adult male has a wing spread of about 3.8 cm. These wings are brown with yellowish markings.
____ 2. White-marked Tussock moth.	b. It feeds chiefly upon shade trees, such as sycamores. The adult has a wing spread of about 25 mm. The wings are gray with wavy dark bands and pale markings.
____ 3. Gypsy moth.	c. The adult male has a wing spread of approximately 31 mm. The wings are light gray with pale markings.

A25. Associate three webbing Lepidoptera defoliators with their descriptions.

Webbing Lepidoptera Defoliators. Many important pests of ornamentals construct webbed tents on limbs and branches of host trees. Others inclose themselves within rolled leaves or leaves tied and webbed together. The large, ugly webs or rolled and tied leaves, combined with the stripping of foliage by the caterpillars, adds to the unsightly appearance of damaged trees.

Fall webworm. The fall webworm is a moth belonging to the order Lepidoptera. It is only important as an ornamental pest in its larval stage, as is the case of all Lepidopteras. It feeds upon shade and fruit trees and is most abundant in the eastern region of the United States but is also found westward to the Rocky Mountains. An unusual characteristic of fall webworms is the forming of a thin white web that incloses the tips of branches on which the worm is feeding. As they grow and foliage within the web is consumed, the web is extended to cover more leaves. Remember this characteristic especially, because it is essential to detect the presence of fall webworms when you conduct surveys.

The larvae are approximately 28 mm long and pale yellowish or greenish. They have a longitudinal greyish stripe down the center of their backs with a yellow strip along each side, and are black and orange spotted.

The adults have pure white wings that may be spotted with black at times. The wing spread of these adults is approximately 25 mm.

Fall webworms spend the winter as pupae in a thin cocoon on the ground. They emerge as adults in late spring and lay their eggs in masses of up to 500 on the bottom of leaves. The eggs hatch in about 10 days and the larvae begin to feed, eating the entire leaves.

Eastern tent caterpillar. The eastern tent caterpillar is a moth that eats entire leaves of shade and fruit trees. It is found from the Rocky Mountains and eastward. These insects construct webs in the forks of main branches in a tree. Unlike the fall webworms, the webs of eastern tent caterpillars do not inclose leaves; they serve only as protective living areas. The larvae must leave the web to feed.

The eastern tent caterpillar is approximately 5 cm long and black with a white longitudinal stripe on its back. On each side of the stripe is a row of alternating pale blue and velvety black spots. It is sparsely covered with light brown hairs.

The adult is robust and has a reddish-brown body and wings. The forewings have two whitish lines crossing them. The male has a wing spread of about 3.2 cm, while the wing spread of the female is only about 12.5 mm.

The adults appear in early summer and lay as many as 300 eggs in wide bands around small twigs of trees. A sticky substance deposited over the eggs hardens and attaches the eggs to the twig. The larvae hatch and overwinter within the eggs, emerging in early spring. At first, the larvae feed upon the egg covering material and then they spin the web.

Spruce bud worm. This moth larva is probably the most destructive leaf roller and tier in the United States. It is a serious pest of spruce, balsam fir, and ponderosa pine. The larvae feeds first by boring within old needles and then tunnels into opening buds. They later tie the tips of twigs together, forming a nest, and when they are full grown, they spin loose cocoons in the nest or on a twig, where pupation occurs.

The adults are active in the summer and lay their eggs on foliage. The eggs hatch and the young larvae spin protective coverings under the bark scales to overwinter. The larvae then become active in the spring, feeding on opening buds.

The adults are attractively striped or spotted in browns or grays. When resting, they appear to be bell-shaped because of the manner in which the wings are folded across their backs. The moths seldom exceed 25 mm in wing spread.

The larvae are greenish and have sparse hairs protruding from tiny raised areas on their bodies.

Exercises (A25):
Match the statements in column B with the pest in column A.

Column A	*Column B*
____ 1. Fall webworm	a. It eats entire leaves of shade and fruit trees. These insects construct webs in the forks of main branches in a tree. The web does not inclose leaves and serves only as a protective living area.
____ 2. Eastern tent caterpillar.	
____ 3. Spruce bud worm.	

Column B

b. Is only important as an ornamental pest in its larval stage. It feeds upon shade and fruit trees. The white web incloses the tips of branches that are being fed upon.

c. It is a serious pest of spruce, balsam fir, and ponderosa pine. The larvae feed first by boring within old needles and then tunneling into the opening bud. The adults are active in the summer and lay their eggs on foliage.

A26. Identify given statements pertaining to bagworms and cutworms as being true or false, and correct those that are false.

Miscellaneous Lepidoptera Defoliators. There are several miscellaneous arthropods that often consume the leaves and needles of ornamentals. The most common of this group are the bagworms and cutworms.

Bagworms. The bagworm is a caterpillar which lives in a silken cocoonlike bag to which is attached bits of leaves and stems from the host plant. The bag, approximately 5 cm long, is attached to the stems and twigs of the host plant. The bagworm is principally a pest of shade trees, shrubs, and hedges, although it favors evergreens of all kinds, especially junipers, cedars, and arborvitae. Affected plants may be partially or totally defoliated.

Cutworms. Cutworms are smooth, plump caterpillars, gray or brownish, and 2.5 to 5.0 cm long when full grown. They are seldom seen because they usually remain hidden under clods of earth or in the topsoil by day. In the evening, cutworms emerge to feed to foliage, buds, green fruits, and succulent growth of ornamentals. Heavy infestations cause severe damage and at times young plants may be killed.

Exercises (A26);

Mark the following statements as being correct (C) or incorrect (I). Correct those that are false.

___ 1. The most common insects in the miscellaneous Lepidoptera defoliators group are bagworms and cutworms.

___ 2. The cutworm is a caterpillar which lives in a silken cocoonlike bag to which is attached bits of leaves or stems from the host plant.

___ 3. The bagworm is principally a pest of shade trees, shrubs, and hedges, although it favors evergreens of all kinds.

___ 4. Bagworms are smooth, plump caterpillars, gray or brownish, and 2.5 to 5.0 cm long when full grown.

___ 5. Cutworms are seldom seen because they usually remain hidden under clods of earth or in the topsoil by day.

A27. Identify given statements as pertaining to the elm leaf beetle, Japanese beetle, or both.

Skeletonizing Defoliators. Leaf beetles, as the name implies, feed on the leaves of plants as adults or larvae or both. The adults are characterized by a great variation in coloration and markings; they are spotted, striped, or patterned in brightly contrasting colors. The larvae are usually soft bodied and sometimes highly pigmented.

The feeding pattern of the adults is often characterized by a skeletonizing of the leaves, generally the lower surface. The larvae and adults consume the upper and lower epidermal layers of the leaf, leaving only the veins and cross veins untouched. Heavy feeding by either the adults or larvae causes a distinct brown or gray appearance of the trees attacked.

Elm leaf beetle. This beetle can be found in almost every region of the United States but is most commonly found in the New England and Mid-Atlantic States. As its name indicates, its preferred food is that of the elm tree.

Both the adult and larval stages feed on the leaves. The adults eat irregularly shaped holes in the leaves in early spring, while the larvae feed on the leaves' undersurface, leaving the upper epidermis unbroken in the summer.

The adult beetle is approximately 6 mm in length. It is dull yellow with black spots on the head and pronotum. It has a black band near the outside of each elytron (wing cover) and a short streak at the base of elytron.

Japanese beetle. This beetle is distributed from Maine to Florida and eastward to the Mississippi River, although it is most abundant in Connecticut, New York, New Jersey, Delaware, Pennsylvania, and Maryland. It feeds upon the foliage of many types of plants as an adult. It also feeds upon the roots of many plants in the larval stage.

The adults appear in June and lay their eggs in the ground. Upon hatching, the larvae (grubs) feed on decaying vegetation and living plant roots. As the weather gets cooler, the larvae burrow deeper into the ground and overwinter. As the weather warms, they begin to work themselves closer to the surface to pupate in May.

The adults are described as being approximately 12.5 mm long and bronzy green in color. The elytra are brown. There are six white spots along each side of the abdomen.

Exercises (A27):

In the blank spaces provided, identify the skeletonizing defoliators by placing an E for elm leaf beetle, J for Japanese beetle, and B for both.

___ 1. Their preferred food is that of the elm tree.
___ 2. Both the adult and larval stage feed on the leaves.
___ 3. The adult beetle is approximately 6 mm in length and is dull yellow with black spots on the head and pronotum.
___ 4. Heavy feeding by either the adults or larvae causes a distinct brown or gray appearance of the trees attacked.
___ 5. It feeds upon the foliage of many types of plants as an adult as well as on the roots of many plants in the larval stage.
___ 6. The adults appear in June and lay their eggs in the ground.
___ 7. The adults are approximately 12.5 mm long and bronzy green in color.

A28. Associate four mining defoliators with their descriptions.

Mining Defoliators. Leaf-mining insects consume the tissues between the upper and lower surfaces of leaves and needles. On deciduous trees, miners make blotchlike or irregular serpentine mines, thus producing brown patches or blotches on leaves. When numerous, they kill the leaves and thus disfigure the plant or tree. On conifers, the needles are hollowed out, and the dried, mined needles have a scorched, sickly appearance. When leaf miners are numerous, growth of plants and trees is retarded, and at times, the plants and trees may be killed.

Holy leaf miner. Holly leaf miners are the larval stage of a small dark or yellowish fly. The maggots are less than 4.7 mm long, with whitish, cylindrical, soft, legless bodies. The head is indistinct and is located at the pointed end of the body. The mouthparts consist of one or two parallel, toothed hooks. The pupae hibernate over the winter within the leaf mines.

Arborvitae leaf miner. Arborvitae leaf miner is the larval stage of a small, gray moth with a wingspread of only 8.3 mm. The larvae are 5 mm long, green with a reddish tinge and black head, and short bristles across the back of each segment. The larvae mine the terminal leaves by eating out the inside. The mined tips turn yellow or whitish and, finally, brown, and stand out prominently against the normal green foliage. In severe cases, all the foliage is mined, and the shrubs turn brown all over. The moths emerge in May and June and lay their eggs in late June.

Basswood leaf miner. The basswood leaf miner is the larval stage of a small, reddish-yellow, wedgeshaped beetle, which passes the winter under leaves and trash of the tree. It becomes active in May, skeletonizing the foliage. Eggs are laid singly in feeding areas and covered with excrement. The larvae start feeding into the leaves in single mines; then several join together in a common mine. Spiny pupae appear in the mines in August. The beetles emerge to do more feeding before hibernation for winter begins.

Birch leaf miner. The birch leaf miner is an important sawfly. It was first discovered in Connecticut in 1923. It is now a major pest of birch in New England, New York, New Jersey, Pennsylvania, and, recently, Oregon. Infested trees look as if they had been blighted by disease.

The mature larva is 6.2 to 12.5 mm long, rather flat, and whitish with black spots on the underside of the thorax and first abdominal segments. This miner passes the winter in a cell in the soil. The adult is a black sawfly, 1.5 mm long; it emerges in the spring about the time leaves are half open and lay its eggs in the new leaves. The larvae first make small, gray, kidney-shaped blotch mines in the leaf. Gradually, half of the leaf turns brown. There are several generations, with the female sawflies laying eggs always in the newly developing leaves. Hence, the first brood is the worst, when all the leaves are new. The later broods infest mostly ends of branches of water sprouts.

Exercises (A28):

Match the statements in column B with the pest in column A.

Column A	*Column B*
___ 1. Holly leaf miner.	a. Is the larval stage of a small, reddish-yellow wedge-shaped beetle which passes the winter under leaves and trash of the tree.
___ 2. Arborvitae leaf miner.	b. The larval stage of a small, dark or yellowish fly. The maggots are less than 4.7 mm long, with whitish, cylindrical, soft, legless bodies.
___ 3. Basswood leaf miner.	c. Infested trees look as if they had been blighted by disease. The mature larvae is 6.2 to 12.5 mm long, rather flat, and whitish, with black spots on the underside of the thorax and first abdominal segments.
___ 4. Birch leaf miner.	d. Is the larval stage of a small, gray moth with a wing spread of only 8.3 mm.

A29. Complete given statements concerning measures that you can take to control ornamental defoliators.

Control of Ornamental Defoliators. When you are controlling these pests with insecticides, always make sure that the insecticide is approved for the use intended. Appendix A of the supplement to Volumes 4, 5, 6, and 7 provides you with a list of chemicals that are recommended for controlling these pests, but you must always read the label of the container to see for sure if you can use it.

Common lepidoptera defoliators and skeletonizing defoliators are easily controlled with insecticidal sprays and dusts.

Leaf and needle miners often are difficult to control because they are concealed between the layers of the leaf. Insecticidal sprays are effective; however, you must provide thorough coverage and repeat the treatment when necessary. Light infestations of needle miners may be controlled by handpicking infested needles or twigs from the tree.

Insects in webbed tents and in rolled and tied leaves usually can be controlled by the insecticidal sprays recommended for general defoliators. Mechanical methods also are useful when infestations are confined to individual trees or single limbs or branches. Destruction of wild cherry trees, a preferred host of the eastern tent caterpillar, is helpful in reducing the populations of this pest. Tents on other trees can be pruned off and destroyed or, on occasion, burned in place. The removal and destruction of rolled and tied leaves also is effective in controlling light infestations on individual ornamentals.

Bagworms are readily controlled by handpicking bags from affected hosts. In situations where handpicking is not feasible, control can be achieved with insecticidal sprays. Chemical control is effective, however, only in the spring and early summer months when the bagworms are feeding and thus are vulnerable to the toxic sprays.

Exercises (A29):

1. Insects in webbed tents and in rolled and tied leaves usually can be controlled by the insecticidal sprays recommended for ____________________.
2. Leaf and needle miners often are difficult to control because they are concealed between the __________ __________ __________ __________.
3. Bagworms are readily controlled by ____________ bags from affected hosts.
4. When controlling ornamental defoliators with insecticides, always insure that the insecticide is approved __________ __________ __________ __________.

A30. Identify given statements pertaining to the importance, description, and control of bark beetles, as true or false.

Importance, Description, and Control of Bark Beetles. Bark beetles and engravers are major pests of coniferous trees in forested areas. Forest trees serve as the breeding place for most species. Ornamentals that are usually forest trees but are growing under unnatural conditions often are attacked and killed. For the most part, both adults and larvae live in the bark or wood of trees. Many species confine their attack to pines, although other conifers and hardwoods often are affected.

Bark beetles and engravers are small, black or dark brown, cylindrical beetles. They are usually less than 6.2 mm long. The larvae are small, soft, white or yellowish-white, legless, strongly curved grubs. Most species are found between the bark and the wood along the stem of the trees. Some bark beetles, however, feed entirely in the corky layer of outer bark. You can recognize all of the bark beetles and engravers by the characteristic pattern of winding galleries constructed by adults or larvae in the cambium tissues beneath the bark. The engravers, as the name implies, etch the wood beneath the bark in the construction of their galleries. Bark beetles, however, do not score the wood. Attacked trees are quickly killed and foliage soon turns a sickly yellow, red, and brown and finally the needles fall to the ground.

Control of bark beetles and engravers is primarily prevention because attacked trees usually are quickly killed and cannot be saved. Individual trees can be protected against attack by spraying bark surface of stems with an approved insecticidal emulsion. Trees damaged through neglect and carelessness are highly attractive to bark beetles and engravers. Measures taken to avoid this damage will decrease the probability of attack by bark beetles and engravers. Cutting and destroying trees previously killed by bark beetles will also lessen the possibility of attack of surrounding shade trees.

Exercises (A30):

Mark each of the following statements "T" for true and "F" for false.

____ 1. Bark beetles and engravers are major pests of coniferous trees in forested areas.

____ 2. Bark beetles and engravers are small, black or brown, cylindrical beetles, usually less than 6.2 mm long.

____ 3. Bark beetles score the wood.

____ 4. The engravers etch the wood beneath the bark in the construction of their galleries.

____ 5. Individual trees can be protected against attack by spraying bark surface of stems with an approved insecticidal emulsion.

____ 6. Attacked trees are quickly killed.

A31. Give details of borer damage and state how to control the ornamental borers.

Ornamental Borer Damage. The larvae of some beetles and moths are borers in the woody tissue of ornamentals. They are a constant threat to, and serious pests of, these plants. Borers attack a wide variety of ornamentals and shade trees, especially dogwood, lilac, apple, ash, birch, rhododendron, pine, locust, maple, sweetgum, and oaks. Since infestations usually begin in weakened trees, the damage caused by wood borers often goes unnoticed until serious injury develops. Injury is caused by larvae tunneling under bark and into the wood. Some confine their attack to the sapwood of the trunks, decreasing the vigor of the host plant and causing foliage to wilt. Others bore into the heartwood of trees. Still others hollow branches and twigs. Wilting leaves on individual branches or twigs are suggestive of their work. The twigs or branches eventually die and are broken by the wind. Dangling dead branches become conspicuous. Close examination of trees attacked by borers usually reveals fine boring dust being pushed from the holes by the larvae as they extend their tunnels. Severe infestations may result in the girdling and eventual death of the tree attacked.

Control. Since the larvae are well protected within the bark and wood, control of borers is very difficult. There are, however, a number of remedial measures that you can take. Since infestations usually start in weakened trees, cultural methods of control are often effective. Application of fertilizers monthly and frequent watering of weakened or newly transplanted trees will increase plant vigor and help them to overcome attacks to some extent. Wrapping the trunks of newly transplanted trees with paper or burlap will lessen the chance of attack. In the early spring, pruning and burning and dying or unthrifty twigs or branches containing borers will reduce infestations. Preventing inadvertent damage to the bark through carelessness will also be helpful in lessening the chance of attack by borers.

Borers within the wood or bark can be killed by injecting carbon disulfide, paradichlorobenzene, or benzene hexachloride paste into the tunnels and sealing the openings with putty. Overwintering borers living just beneath the bark of infested trees can be killed by applying such an insecticidal residual as a bark wash in the spring.

Exercises (A31):

1. The larvae of some beetles and moths are ________ ________ in the woody tissue of ornamentals.
2. Injury is caused by larvae ________ ________ ________ and into the ________.
3. Close examination of trees attacked by borers usually reveals ________ ________ ________ being pushed from the holes by the ________ as they extend their ________.
4. Wrapping the trunks of newly transplanted trees with ________ or ________ will lessen the chance of ________.
5. Borers within the wood or bark can be killed by injecting ________ ________, ________, or ________ ________ paste into the ________ and sealing the openings with ________.

A32. Associate given sapsuckers with their descriptions and the control measures used on them.

Description and Control of Ornamental Sapsuckers. Many insects and some other arthropods feed only on plant sap. Spotting, discoloration, malformation, and general devitalization of the foliage, twigs, or other plant parts are caused by insects and mites that have mouthparts adapted for piercing plants and extracting sap. Solid parts of the plants are never consumed. The injury consists of enlarged growth (galls): foliage disturbances, such as bleaching or yellowing: or deformations, such as curling. All parts of all plant species are subject to attack by these pests, but usually a given species infests only a particular plant part. Most sapsucking insects belong to the orders Hemiptera and Homoptera, but some are mites (class Arachnida) and many of the gall formers are wasps (Hymenoptera) and flies (Diptera).

Aphids. Aphids are sapsucking insects that cause a general devitalization of the part of the plant fed upon. When feeding is sufficiently intense and continuous, branch killing and even tree killing results. Aphids commonly produce large quantities of honeydew; sometimes during heavy infestations, the excreted liquid may appear as mist falling from the tree. This honeydew often spots or forms a glistening coat on the leaves, cars, and other objects located below. Various insects utilize honeydew as food. Some species of ants also care for and protect the aphids, even moving them to new feeding areas, thereby forming a mutually beneficial relation.

The adult aphids are small insects, 0.8 to 6.2 mm long, with delicate, soft, globular to pear-shaped bodies that are colored variously yellow, red, green, gray, blue, or black. The adults occur as both winged and wingless forms; the winged forms have two pairs of delicate membranous wings that are usually held rooflike over the body. There are three pairs of long, slender thoracic legs with two-segmented tarsi. The antennae are prominent and threadlike, with three to six segments. The beak appears to arise from between the front legs. The nymphs resemble adults in most characteristics except that they are smaller in size, always lack wings, and are sexually immature.

The life cycle of some aphids is simple, whereas others have a complex type of development. The latter can be outlined in a general way as follows. They pass the winter as eggs on the primary host plant. The eggs hatch in the spring to produce nymphs, which all mature as wingless females. They reproduce without mating (parthenogenesis), and some (Aphididae) give birth to living young (viviparous), whereas others (Adelgidae) always lay eggs (oviparous). Several additional, similarly produced, asexual, wingless generations may be produced on the primary host before a winged asexual generation develops. These migrate to the secondary host plant, where wingless females are produced again for a number of generations. A second, winged, migrating generation, consisting solely of females, develops later in the year, and these return to the primary host plant. A bisexual generation then develops. These mate, and each female lays one overwintering egg. See Appendix A of the supplement to Volumes 4, 5, 6, and 7 for pesticide recommendations.

Scale insects. Scale insects are so called because many species secrete a scalelike wax coating over their backs, and others resemble bark scales. These insects cause general devitalization and death of the infested parts by extracting plant sap and by injecting toxic saliva into the host plant tissues. Different species attack different parts of the hosts, but most infest the twigs and smaller branches. The soft scales frequently produce large amounts of honeydew, which attracts nectar-feeding insects. The honeydew that is not used falls on the leaves, twigs, and branches located below, where it forms a medium on which black sooty molds grow. Only a few species are troublesome forest pests, but many are injurious to shrubs and to shade and ornamental trees. A few species produce useful products, such as shellac; and in past times, some scale insects were the sole source of certain brilliant dyes.

In the adult female, the body may be flattened, globular, hemispherical, saclike, elongated, or circular. Sometimes it is covered with wax in the form of powder, cottony masses, or a continuous scalelike layer. The females are always wingless, and the legs, antennae, and compound eyes are reduced or absent. Most species are sedentary and cannot move from the place where they settle after the crawler stage. The males, though seldom observed, usually have a pair of membranous wings. The legs are well developed, the antennae are long, with 6 to 13 segments, and the beak is absent. The nymphs of the first instar (crawlers) of both sexes have legs, antennae, functional mouthparts, and are mobile; other nymphal instars of both sexes are scalelike, with male scales being smaller and often more elongate. Most species lay eggs, but a few reproduce by giving birth to living young (viviparous). The crawlers disperse to new places on the same host plant or get carried to new host plants by wind, birds, or other animals. There may be one to three additional instars and one to six generations per year, depending on the species and the length of the summer season. Insecticides are seldom used for protecting forest trees but commonly are used on shrubs and shade trees. Mineral oils (3 percent emulsions) can be used as dormant sprays on most decidous trees except walnut, beech, and sugar maple, which are injured by oils. The heavy, dormant oil sprays also may injure evergreens; therefore, only the lighter, milder, summer oil emulsions are suitable. Dormant oils are best applied in the early spring before the buds begin to expand, but during a time when the temperature does not drop below freezing for at least 24 hours following application. See Appendix A of the supplement to Volumes 4, 5, 6, and 7 for pesticide recommendations.

Mealybugs. Mealybugs are closely related to the scale insects. They are small in size and are covered with a soft and fine, white, granular material which forms long cottonylike threads over the body. Mealybugs damage hosts by sucking juices from plants in much the same manner as is done by the scale insects.

There insects can be controlled effectively by using the same methods as described for aphids in Appendix A of the supplement to Volumes 4, 5, 6, and 7.

Spider mites. Spider mites are minute, reddish or yellowish spiderlike arthropods barely visible to the naked eye. Their bodies are rounded, shiny, and covered with fine hairs.

Spider mites infest most ornamental plants and many shade trees. They feed by sucking juices from the underside of leaves and tender parts of plants. The result of their feeding is a stippled appearance of the foliage, which later discolors and dies. The lower surfaces of leaves on infested plants have a residue of cast skins, eggs, and webbings.

Spider mites can be controlled to some extent by destroying weeds and brush adjacent to ornamental plants. Chemical controls would be the same as for aphids and mealybugs.

Leafhoppers. Leafhoppers are very small, slender, delicate insects. The adults are variously colored and hold their wings over the back in tentlike fashion. They are very active and hop a considerable distance when disturbed.

Leafhoppers attack a wide variety of grasses, shrubs, and shade trees. They injure plants in various ways. The sucking of plant juices causes a withering and curling of the leaves, the killing of tender tips, and the dying of the edges of leaves. Some species transmit plant diseases, mor so to cultivated crops than to ornamental and shade trees.

Controlling leafhoppers involves the same measures as for aphids. You can find the pesticides in Appendix A of the supplement to Volumes 4, 5, 6, and 7.

Spittlebugs. Adult spittlebugs resemble leafhoppers in appearance, except they are more heavily bodied. The name is commonly applied to the nymphs, which secrete a frothy protective foam around themselves.

Spittlebugs are pests of ornamentals and conifers. Some species have alternate hosts in nymphal and adult forms. They suck large quantities of sap from plants and cause numerous small pinholes in phloem and bark tissues. Needles of heavily infested trees turn brown, and twigs and branches are killed. In severe infestations, hosts may be killed in 2 to 3 years.

To control spittlebugs, follow the control outlined in Appendix A of supplement to Volumes 4, 5, 6, and 7 for aphids.

Lacebugs. Lacebugs are small, rectangular insects with an expanded prothorax extended and rounded, resembling a hood. The outer pair of wings are strongly veined and lacelike and are held flat over the back. The nymphs are frequently covered with spines.

Lacebugs attack many shrubs and shade trees. The adults and nymphs feed by sucking juices from their hosts, usually from the undersurface of leaves. Damaged leaves have a spotted, grayish appearance on top and a black, shiny, varnishlike excretment and cast skins on the undersides. Severe infestation cause leaves to turn brown and finally to drop.

Lacebugs can be controlled effectively by following the procedures outlined for aphids in Appendix A of supplement to Volumes 4, 5, 6, and 7.

Thrips. Thrips are very small insects varying in size from less than 1.0 to 1.6 mm in length. They are slender and usually are blackish, brownish, or yellowish. Most flowering plants and shrubs are subject to attack by thrips. They feed on the tissue of the foliage, buds, flowers, and bulbs by puncturing the surface and sucking juices from the part attacked. Buds may fail to open. Flowers may be deformed, blotched, or streaked. Foliage attacked loses its rich colors and develops a characteristic yellowish or silvery appearance. Usually, the foliage does not drop prematurely; therefore, the off-color appearance generally lasts until the end of the season. In addition to the damage mentioned above, some species are known to carry certain virus diseases of flowering plants.

Control of thrips is difficult because the minute insects hide in the sheaths of leaves and flower stems as well as within the flowers themselves. It is difficult to reach them with sprays, and repeated applications are often required.

Exercises (A32):

Match the statements in column B with the pests in column A. More than one statement may apply to each pest. Refer to Appendix A when necessary.

Column A

___ 1. Aphids.
___ 2. Scale Insects.
___ 3. Mealybugs.
___ 4. Spider mites.
___ 5. Leafhoppers.
___ 6. Spittlebugs.
___ 7. Lacebugs.
___ 8. Thrips.

Column B

a. Can be controlled by using malathion. Cover foliage thoroughly, including underside.
b. Can be controlled by using dimethoate. Cover foliage thoroughly.
c. They are reddish or yellowish arthropods barely visible to the naked eye. Their bodies are rounded, shiny, and covered with fine hairs.
d. A few species produce useful products such as shellac, and in the past some were the sole source of certain brilliant dyes.
e. Are small, rectangular insects with an expanded prothorax, extended and rounded, resembling a hood.
f. Resemble leafhoppers in appearance, except they are more heavily bodied.
g. They are slender and usually are blackish, brownish, or yellowish. Most flowering plants and shrubs are subject to their attack.
h. Very small, slender, delicate insects. The adults are variously colored and hold their wings over the back in tent-like fashion.
i. They are small and are covered with a soft and fine, white, granular material which forms cottonylike threads over the body.

A33. Complete given statements concerning the description, damage, and control of ornamental gall-forming pests.

Importance, Description, and Control of Ornamental Gall Formers. Most of the gall-producing insects are wasps (Hymenoptera; Cynipidae) or midges (Diptera; Cecidomyiidae), but galls are also caused by aphids, chermids, and phylloxera (Homoptera, Aphididae, Chermidae, and Phylloxeridae), mites (Arachnida), and even the larvae of some beetles (Coleoptera, Buprestidae, and Cerambycidae). Many species of these pests are able to stimulate plant tissues so the abnormal swellings (galls) are formed on the leaves, twigs, or roots. These galls vary in size, shape, and structure according to the species of pest and plant involved; therefore, specific identification usually can be made solely from the characteristics of the galls. Insect galls can be differentiated from other types of galls because they contain one or more chambers or depressions in which the insects are or have been. Sometimes, the insects become completely enclosed by the plant tissues; whereas for other species, there is at least one opening to the outside. Galls on trees seldom cause serious damage, but they sometimes make shade trees unsightly. All species of plants are attacked, but the oaks, hickories, poplars, spruces, and hackberries are most commonly infested. The life cycle of these gall formers are diverse and sometimes complex. The adults commonly appear early in the spring at the time plant growth starts, so that larval growth and the resulting gall formations occur during the period of most active leaf and terminal plant growth. Only rarely are control measures used against gall formers. See Appendix A of supplement to Volumes 4, 5, 6, and 7 for pesticide recommendations.

Exercises (A33):

1. Most of the gall-producing insects are __________ __________ or __________.
2. Many species of these pests are able to __________ __________ plant tissues so that abnormal __________ (galls) are formed on the __________, __________, or __________.
3. __________ on trees seldom cause serious damage, but they sometimes make shade trees __________.
4. To control wasps indoors, you would use __________ __________ and apply it at __________ or in early __________ when the pests are least active.
5. Insect galls can be differentiated from other types of galls because they contain one or more __________ __________ or __________ in which the insects __________ or __________.

A34. Discriminate between correct and incorrect statements pertaining to the overall survey and control methods for ornamental pests.

Overall Survey and Control Methods for Ornamental Pests. The first essential for effective control of insect pests is vigilance and an interest in looking for insects and signs of their damage. To detect the presence of insects before they cause serious damage to valuable trees and shrubs, you should carefully examine the plants at least once a week during the growing season. You should examine deciduous trees in winter also, when you can see scale insects more easily than when the trees are in leaf.

To control ornamental pests effectively and economically, you first must identify the pests and the host plants. Then, select your insecticides, prepare the correct dosages, decide on the proper application, and select your equipment.

Selection of insecticides. Selection of insecticides usually follows three basic rules. Use a stomach insecticide for pests with chewing mouthparts; use a contact insecticide for those with sucking mouthparts; and use a fumigant for larvae, such as wood borers.

In order to simplify instructions and to avoid complicated storage problems, select and restrict the number of insecticides to the lowest feasible minimum consistent with effective results.

Preparation of correct dosages and the proper application of insecticides. Insecticides that are effective in the destruction of pests are, with few exceptions, toxic to humans. This is also true of most of the solvents used in the preparation of insecticides. However, no serious effects will normally result to control operators or to human and animal populations exposed to the treated environments if insecticides and application rates given in Appendix A of supplement to Volumes 4, 5, 6, and 7 are followed, and if pesticides are applied only by or under the direct supervision of trained and certified personnel as required by Department of Defense directives.

Spray injury may occur when plants are sprayed under improper conditions. Avoid injury of this kind by taking the following precautions.

- Do not apply dormant oil sprays in the fall. Apply dormant oil sprays from January 1 until buds swell in the spring.
- Do not apply dormant oil sprays during sudden drops of temperature to below freezing. A good rule to follow is to apply dormant oil sprays only when the temperature is above 40° F (4.48° C).
- Do not apply dormant oil sprays on maples, beeches, walnuts, or Japanese flowering cherry trees of the varities Yoshino, Akebono, and Benihigan, which are sensitive to oil injury.
- Do not spray summer oils when the temperature is above 86° F (29.68° C), particularly under high humidity and drought conditions.

Selection of equipment. Spraying and dusting equipment varies in size and type from the small dusters and knapsack sprayers that are suitable for a few small shrubs to large mechanical dusters, hydraulic sprayers, mist blowers, airplanes, and helicopters that are used on large shade trees and forested areas.

Dusting of insecticides in some cases may be less troublesome, but it is effective against fewer insect pests. Sprays and mists have a distinct advantage over dusts in that the loss from drift is less because they adhere better to plants.

Hydraulic sprayers and mist blowers, in most cases, complement rather than replace each other. Each has its particular advantages in the application of spray materials. For example, the spray hose gives the hydraulic sprayer much more maneuverability for spraying in congested areas around plantings, or in areas inaccessible to heavy equipment. The mist blower, however, has the advantage over the hydraulic sprayer in spraying along streets, parkways, and open areas where ample space is provided for maneuvering the equipment. Under these conditions, the mist blower can spray large trees more rapidly and at lower cost than the hydraulic type of sprayer. Wind is more of a hindrance in spraying with the mist blower than with the hydraulic sprayer. The tops of tall trees can be sprayed satisfactorily with the mist blower only where there is relatively little wind. More skill is required on the part of the operator in obtaining proper spray coverage with the mist blower than with the hydraulic sprayer. This is because of the wind factor and relatively low volume of concentrated spray material used for obtaining spray coverage by the mist blower as compared to the large volume of dilute spray applied by the hydraulic sprayer. Separate and mark all spraying equipment that you use to apply herbicides, including hoses and nozzles. *Do not use this equipment* for spraying insecticides on trees and shrubs.

Protection of automobiles. When you must spray in areas where cars are parked, put an announcement in the Daily Bulletin or other station publication and post proper warning signs at least 1 day before the spray operation. These notices should give the car owners ample time to part their cars elsewhere during the period of spraying.

Recommendations for ornamental pest control. Trees and shrubs that are maintained in a healthy growing condition are less likely to become seriously damaged by insect pests than those that are suffering from injury caused by improper pruning, mowing, cultivation, lack of water, low soil fertility, and poor soil condition.

To assist in maintaining trees and shrubs in a healthy condition, it is often necessary to take preventive measures to protect them from harmful insect pests. Under forest conditions, these losses are usually offset by the regeneration of new plants, but under cultivated conditions, costly replanting is necessary. Careful selection of plant materials that are healthy, vigorous, and resistant to insect attack, as well as sanitation through pruning and burning

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infested wood, are essential preventive measures. It is important that a preventive control program be developed for the area concerned.

Insecticide recommendations are given in Appendix A of the supplement to Volumes 4, 5, 6, and 7. These recommendations are not all inclusive for all insects attacking shrubs, trees, and forested areas everywhere in the United States, but they do form a suggested guide for the development of a major command installation preventive control program based on local insects and host plants. You should coordinate with the area or command entomologist in the identification and control of pests attacking shrubs, trees, and forested areas on Department of Defense installations.

Exercises (A34):

Mark the following statements as being correct or incorrect by placing a C for correct and an I for incorrect.

___ 1. The first essential for effective control of insect pests is vigilance and an interest in looking for insects and signs of their damage.

___ 2. Use a contact insecticide for pests with chewing mouthparts.

___ 3. Use a stomach insecticide for those with sucking mouthparts.

___ 4. Use a fumigant for larvae, such as wood borers.

___ 5. Do not apply dormant oil sprays in the fall.

___ 6. Hydraulic sprayers and mist blowers, in most cases, complement rather than replace each other.

___ 7. When it is necessary to spray in areas where cars are parked, an announcement in the Daily Bulletin or other station publication should be made and proper warning signs posted at least 1 day before the spray operation.

___ 8. Do not spray summer oils when the temperature is above 80° F, particularly under high humidity and drought conditions.

3-2. Turf Pests

The pests discussed within this section include insects, nematodes, snails, slugs, and plant fungi. The grounds on Air Force installations must be maintained in a state that is pleasing to the eye and in a condition that will prevent rain and wind erosion. Thus, you must be able to recognize the effects of pests on turf and grasses. You must also know what controls to use to maintain turf and grass free from these damaging pests.

A35. Relate given soil and root infesting insects with their descriptions.

Soil and Root Infesting Insects. Soil and root infesting insects include grubs (larvae) of many beetles, mole crickets, wireworms, billbugs, and ants. This objective will describe these pests to enable you in recognizing them so that you can implement the proper controls that are outlined in Appendix A of the supplement to Volumes 4, 5, 6, and 7.

Grubs. There are numerous species of beetles whose larvae, or grubs, attack the roots of grasses during the grub's underground development. They are whitish to grayish and, except for the larvae of the green June beetle, lie in a curled position.

a. May or June beetles. Adults are 12.5 to 18.8 mm long, blackish-brown beetles. They are most abundant between April and mid-July, depending on which of more than 200 species they may be. Grubs of some species remain in the soil 2 or 3 years. They remain inactive well below the sod during the winters, but come up again to feed upon grass roots during warm weather. May beetles are found throughout the country.

b. Japanese beetles. Japanese beetle grubs are about 25 mm long when mature. They feed upon the roots of grasses and of various other plants from August through October and again in April. Beetles appear in May or June, remain for 6 weeks or so, and are well known for their destructive mass attacks on berries, orchard fruits, truck and garden crops, ornamentals, and shade trees. They occur in varying numbers from southern Maine southward into South Carolina and westward into Ohio and West Virginia, with isolated colonies existing in several other states westward to the Mississippi River. The spread of the Japanese beetle has been retarded by a cooperative Federal-State regulatory program in which 5 percent of the area of the United States is under quarantine.

c. Green June beetle. The body of the green June beetle is almost an inch long, slightly flattened, and grey green with yellow edges. It is active from June through August. The larva of the green June beetle is distinctive in that it is not curled and that it crawls on its back while searching for decaying organic matter on which it lives. Harmful holes in turf and little mounds of earth result from this exploration. There is only one generation per year. Green June beetles are found mostly in the Southern States, but frequently as far north as Long Island.

d. Masked chafer. The masked chafer beetle is 12.5 mm long, brown, and often observed around lights on warm humid evenings from June to September. Larvae are sometimes called annual white grubs because the life cycle is completed in 1 year. They attack the roots of grass. The northern masked chafer is found from Connecticut south to Alabama and west to California. The southern masked chafer is common the Southeastern States and is found in Iowa and Illinois.

e. Rose chafer. The adult rose chafer is 12.5 mm long, yellowish brown, and has long spiny legs. It is found in late spring or early summer. The grub is about 18.8 mm long and slightly narrower than most other grubs discussed here. There is one generation per year. Turf damage by this species is generally less severe than that done by other grubs, but it may be bad in sandy areas. Rose chafers are found in the eastern United States and west to Colorado and Texas.

f. European chafer. European chafers are tan to chocolate brown beetles, 12.5 mm long, that appear in June and July. Their larvae, which are generally similar to other chafer grubs, complete their development in 1 year and are serious turf pests in New York State. Isolated infestations have been found in Connecticut and West Virginia.

g. Oriental beetle. Oriental beetles are broad-bodied, spiny-legged beetles, 15.6 mm long, varying in color pattern, but usually straw colored with some dark markings on the body. They appear in late June through August. These larvae are difficult to distinguish from several of the grubs already described. The life cycle is usually completed in 1 year, but the grubs may pass two winters in the soil. They kill lawn grass by eating off the roots close to the soil surface. They are found in Connecticut, southeastern New York, and northern New Jersey.

h. Asiatic garden beetle. Adult beetles are only 9.4 mm long, cinnamon brown, and appear velvety. The underside of the body is covered with short yellow hairs. They are active only at night, are troublesome on many garden and ornamental plants, and are most prevalent from mid-July to mid-August. The larvae have more slender bodies than most of the other related grubs. They usually damage the roots of grass in association with weeds that afford some shade.

i. White-fringed beetles. These snout beetles are dark grey, slightly less than 12.5 mm long, with pale white margins on the wing covers extending along the prothorax. The beetles are found from early May to October. The full grown larvae are about 12.5 mm long, yellowish white, and almost hairless. They chew away the lower part of the stem and taproot of many kinds of plants and may sometimes become troublesome in turf. There is one generation per year, and the distribution is currently confined to the Southeastern States.

j. Rhinoceros beetle. The rhinoceros beetle is 5 cm long. Its larva is 7.6 cm long. It is a pest of lawns in Florida, where it is found during the summer and fall.

Mole crickets. These peculiar looking creatures are brownish, sometimes almost olive colored insects 3.8 cm long with powerful forelegs adapted for digging. Mole crickets make burrows that resemble tiny mole tunnels in the soil. These crickets disturb grass seedlings and cut off established grass roots by their tunneling. There is one generation per year. They are most numerous in the South Atlantic and Gulf Coast States from North Carolina to Texas.

Wireworms. The adults of wireworms are slender brown "click beetles." The larvae, or wireworms themselves, may be 12.5 mm to 3.8 cm long at maturity and are usually hard, yellow brown, smooth, and wormlike. They bore into the underground parts of numerous farm crops and other plants. This boring into and feeding in grass roots and stems causes withering and death. Wireworms remain in the soil for 2 to 6 years while developing, moving only a few yards during this time. Their distribution is cosmopolitan, but they are most serious in areas of high rainfall or where irrigation is practiced.

Billbugs. Adult billbugs are various colored beetles, 5.0 to 18.7 mm long, with long snouts or bills at the tip of which are strong jaws. With these jaws, adults burrow into grass stems for food and for the deposition of their eggs. Leaves are also fed upon. The larvae have soft, white bodies, hard, yellow to brown heads, and are rather small. They feed upon fibrous grass roots of turf and small grains throughout the grasslands and cultivated areas of the United States.

Ants. There are numerous species of ants that have become associated with humans and their property. Most are small, 2.5 to 6.3 mm long, ranging in color from yellow to black. Several of these, such as the cornfield and little black ant, are frequent inhabitants of established lawns throughout the country. The Argentine and pavement ants are found in lawns in the Southeast and Atlantic Coast States, respectively. Their ant hills and underground nests smother or destroy the roots of surrounding turf. The southern fire ant is spreading northward from the Gulf Coast States, where it forms loose mounds or numerous scattered craters in grassed areas. Texas leaf-cutting ants damage turf by establishing unusually deep nests, by provisioning these nests with cut leaves of plants for fungus growing purposes, and by stealing grass seed. This ant is found in Texas and Louisiana.

Exercises (A35):

Match the statements in column B with the pests in column A.

Column A

___ 1. Grubs.
___ 2. May or June beetles.
___ 3. Japanese beetles.
___ 4. Green June beetles.
___ 5. Masked chafer.
___ 6. Rose chafer.
___ 7. European chafer.
___ 8. Oriental beetle.
___ 9. Asiatic garden beetle.
___ 10. White-fringed beetle.
___ 11. Rhinoceros beetle.
___ 12. Mole crickets.
___ 13. Wireworms.
___ 14. Billbugs.
___ 15. Ants.

Column B

a. Well known for attacks on berries, orchard fruits, truck and garden crops, ornamentals, and shade trees.
b. 12.5 mm long, brown, and is often observed around lights on warm humid evenings from June to September.
c. These snout beetles are dark grey, slightly less than 12.5 mm long, with pale white margins on the wing covers extending along the prothorax.
d. Most are small, 2.5 to 6.3 mm long, ranging in color from yellow to black. Their underground nests smother or destroy the roots of surrounding turf.
e. Attack the roots of grasses during its underground development. They are whitish to grayish and, except for the larvae of green June beetles, lie in a curled position.
f. Its body is almost an inch long, slightly flattened, and gray green with yellow edges.

Column B

g. Are broad-bodied, spiny-legged beetles, 15.6 mm long, varying in color pattern, but usually straw colored with some dark markings on the body.
h. The adults are slender brown "click beetles." Their larvae may be 12.5 mm to 3.8 cm long at maturity, usually hard, yellow brown, smooth, and wormlike.
i. Adults are 12.5 to 18.8 mm long, blackish-brown beetles. They are most abundant between April and mid-July.
j. They vary in color, are 5.0 to 18.7 mm long, with long snouts or bills at the tip of which are strong jaws.
k. The adult is 12.5 mm long, yellowish brown, and has long spiny legs. It is found in late spring or early summer.
l. These creatures are brownish, sometimes almost olive colored, insects 3.8 cm long, with powerful forelegs adapted for digging.
m. Are tan to chocolate brown beetles, 12.5 mm long, that appear in June and July.
n. Adult beetles are only 9.4 mm long, cinnamon brown, and appear velvety. The underside of the body is covered with short, yellow hairs.
o. It is 5 cm long, and its larva is 7.6 cm long. It is a pest of lawns in Florida.

A36. Associate given leaf and stem damaging insects with their damaging characteristics and general descriptions.

Damaging Insects to Leaves and Stems of Grasses. Insects with this category include the sod webworm, cutworm, lucerne moth, fiery skipper, and grasshopper.

Sod webworms. Adult moths of the webworms are 12.5 to 25 mm long are yellowish brown to dirty gray. They hide in the grass during the day, coming out in late afternoon or evening. The webworms themselves are about 18.8 mm long, light brown, and covered with fine hairs. They build short, silk-lined tunnels in the ground at the base of the grass plants. From these they emerge at night to feed on the grass, often dragging bits of the blades into their burrows. Sod webworms prefer new lawns. Ragged patches in the turf are the first signs of damage; however, in heavy infestations, large areas of turf may be completely killed. Most of the important species have several generations per year. Webworms occur throughout the United States.

Armyworms. Two of this group are important to turf: the armyworm and the fall armyworm. The armyworm adult is a pale brown moth with a single white dot in the center of each forewing. The forewing of the fall armyworm adult is dark grey and mottled, while the hindwing is grayish white. Both have a 3.8 cm wing spread. The caterpillars resemble each other more closely, having a basic tan to green color with three yellowish-white hairlines down the back from end to end. Armyworms hide in the soil by day and feed first on the stems and then on the leaves of grasses at night. Fall armyworms do not leave the grass plants to hide. When these species are numerous, they may devour plants to the ground, causing more or less circular bare areas in turf.

Cutworms. There are many species of cutworms. Some species remain in the soil and feed upon roots and underground parts of stems; others cut grass off at the soil line, and still others devour the blades. Damage is done at night, leaving small, elongated, or irregular, closely cropped brown spots in the turf. Cutworms are of worldwide distribution; however, certain species are found primarily in southern and others in northern climates.

Lucerne moth. The adult is grayish brown with two pairs of dark spots on each forewing. The larvae of this moth may occasionally attack turf, particularly in California.

Fiery skipper. Adults are small yellowish-brown butterflies. Early larval attack results in isolated, round, bare spots 1 to 2 inches in diameter. The spots may become numerous enough to destroy much of a grassed area. This insect is an occasional pest of lawns in California.

Grasshoppers. There are more than 100 species of grasshoppers that may feed on range vegetation or grassed areas. Most of these are 2.5 to 5.0 cm long and vary widely in coloration from mottled tones of tan to degrees of green and yellow, with or without spots and stripes. The migratory grasshopper and two other species that have the typical migratory habit are highly destructive during outbreaks. These adults fly in swarms and, as a group, lay their eggs in well-defined beds. There are one or two generations per year. These grasshoppers have occasionally destroyed grass and other vegetation cover over wide areas. They cut stems and blades close to the ground, often eating only part of what they have selected. While grasshoppers are found throughout the world, most extensive damage in this country has occurred primarily in the Central and Western States.

Exercises (A36):

Match the statements in column B with the insects in column A.

Column A

___ 1. Sod webworm.
___ 2. Armyworm.
___ 3. Cutworm.
___ 4. Lucerne moth.
___ 5. Fiery skipper.
___ 6. Grasshopper.

Column B

a. The adult is grayish brown with two pairs of dark spots on each forewing. The larvae of this moth may occasionally attack turf, particularly in California.
b. Most are 2.5 to 5.0 cm long and vary widely in coloration from mottled tones of tan to degrees of green and yellow, with or without spots and stripes. They cut stems and blades close to the ground, often eating only part of what they have selected.

Column B

c. The caterpillars resemble each other closely, having a basic tan to green color with three yellowish-white hairlines down the back from end to end. They hide in the soil by day and feed first on the stems and then on the leaves of grasses at night.

d. Adults are small yellowish-brown butterflies. Early larval attack results in isolated, round, bare spots 1 to 2 inches in diameter.

e. Some species remain in the soil and feed upon roots and underground parts of stems; others cut grass at the soil line; still others devour the blades.

f. Moths of this insect are 12.5 to 25 mm long and are yellowish brown to dirty gray in color. They feed at night, often dragging bits of blades into their burrows.

A37. Discriminate between true and false statements pertaining to sucking insects and correct those that are false.

Sucking Insects Destructive of Turf and Grasses. This group of insects includes the leaf bugs, chinch bugs, leafhoppers, and scale insects.

Leafbugs. This bug feeds on certain lawn grasses, killing the grass in spots. The leafbug is found throughout the United States, but it is best known in California lawns.

Chinch bugs. An adult chinch bug is about 4.2 mm long. It is black with white markings. However, the immature, or nymph, forms cause most of the injury. At birth they are one-half the size of a pinhead and are bright red with a white band across the back. They increase in size and darkness with each of four molts. There are normally two generations, with the adults overwintering in clumps of perennial grasses or similar shelter. There may be a partial third generation in the southernmost States. Cultivated and wild grasses are attacked, causing yellowish spots at first, which then turn brown as the turf dies. The chinch bug has been found throughout the United States and is one of the most destructive of the turf-attacking insects.

Leafhoppers. There are several species of the leafhopper that feed upon and injure turf. They are less than 5.0 mm long and may be green yellow or light tan. Adults hold their wings over their backs in wedge-shaped, tentlike position, but they fly short distances readily when disturbed. Both nymphs and adults suck plant juices, and especially in dry hot weather, they may cause extensive off-color of lawns (gray to a light brownish yellow in spots). This effect may be mistaken for damage due to dry weather or disease. Leafhoppers are found worldwide.

Scale insects. There are several species of scale insects that injure turf, primarily in the Southern States. Being tiny and inconspicuous, these true bugs are frequently overlooked. They are usually round or oval with a waxy covering. Eggs develop into active crawlers or nymphs. These soon insert their backs into plant tissue and suck out plant juices. The following are the common scale pests of cultivated turf.

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a. Rhodegrass scale. The adult is 3.1 mm in diameter, globular, and dark purplish brown. It is covered with a white cottony secretion. Both the adults and nymphs cause turf browning by attacking chiefly the plant crowns of Bermuda grass and St. Augustine grass. There may be five generations a year. This scale is found in southern Texas, Louisiana, Florida, and California.

b. Bermuda grass scale. Adults are 1.6 mm long, oval, and covered with a white, hard secretion. Nymphs and adults damage Bermuda grass, where with heavy infestations, they kill the grass and leave brown patches. Bermuda grass scale is most prevalent in Florida.

c. Ground pearls. These are scale insects, measuring 1.6 mm across, that have a hard, cream-colored covering which encloses their bodies so that they look like small, round pearls. The feed on the roots of Bermuda grass in the South and Southwest, and centipede grass in the South, causing turf to turn brown and eventually die.

Exercises (A37):

Mark the following statements as being correct (C) or incorrect (I). Amend any false statements.

___ 1. The leafbug feeds on certain lawn grasses and kills the grass in spots.

___ 2. At birth, the chinch bug is one-half the size of a pinhead and are black with a white band across the back.

___ 3. The leafhoppers are less than 5 mm long and may be green yellow or light tan. Both nymphs and adults suck plant juices, especially in dry, hot weather.

___ 4. The common scale insects of cultivated turf are the Rhodegrass scale, Bermuda grass scale, and ground pearls.

A38. Complete given statements concerning the survey and control measures for turf and lawn-damaging insects.

Survey and Control of Turf and Lawn-Damaging Insects. Blotchy, dying grassed areas may be the result of disease, nutritional unbalance, drought, or insect damage. Check first for the presence of insects. Extensive injury to turf by many insects may be largely prevented through initial surveillance and a few, simple inspection techniques.

Grub populations are best evaluated in the fall before cold weather or after the soil has been warmed by the sun in the spring. Cut three sides of a strip of sod 1 foot square by 2 or 3 inches deep, laying it back by using the uncut side as a hinge. Knock grubs from the exposed grass roots and soil with a trowel or blade. Make several such samples at random in an average sized lawn. A half dozen or more grubs per square foot indicates need for control.

Chinch bugs may be detected by the use of a tin can with both ends removed. One end of this cylinder is pushed into the ground in a yellowed portion of the damaged turf. Fill the cylinder with water. If chinch bugs are present they will float to the surface within several minutes.

Sod webworms, armyworms, and cutworms may be brought to the surface by applying 1 tablespoonful of pyrethrum extract in 1 gallon of water to 1 square yard of turf. If you see 12 to 16 of them per square foot, apply a recommended insecticide.

You can detect wireworms by passing broken-up sod through a hand sifter made of a piece of four-mesh hardward screen attached to a frame. Allow the resulting soil to fall upon a second sifter, made with standard window screen, where you can see the shiny, yellow wireworms. To control these insects, follow the use recommendations provided on pesticide labels.

Exercises (A38):

Complete the statements.

1. Grub populations are best evaluated in the ______ __________ before cold weather or after the ______________ has been warmed by the _______ in the ___________ .
2. Cut _____________ sides of a strip of sod 1 foot square by _______ _________ ______ inches deep, laying it back, using the uncut side as a ___ ____ .
3. A ______________________ or more __________ per square foot indicates need for control.
4. Wireworms may be detected by passing ________ sod through a hand sifter made of a piece of ________ - ________ hardware _______________ attached to a frame.

A39. Complete given statements concerning the general characteristics of nematodes.

Nematodes. Nematodes are often serious plant pests which require control. Nematodes, or eelworms, belong to the class Nematoda of the phylum Nemathelminthes. Most mature nematodes are quite small, requiring magnification to be seen, but some parasitic roundworms grow to a length of 0.9 meters. Nematodes are found nearly everywhere in nature, from arid deserts and hot springs to polar seas and ice caps, and from beach sands to the bottoms of lakes and rivers. Many are free living, while others are parasites of plants and animals. Over 50 species parasitize man. It has been estimated that as many as 80,000 species parasitize vertebrate animals, that a larger number of species parasitize invertebrate animals, and that a still greater number are parasites of plants or are free living in soil or water. The total number of individual nemotodes is beyond human comprehension. A tablespoonful of ooze from the sea bottom may contain thousands, and the top acre-foot of cutivated soil may contain many billions. Most nematodes in the soil are harmless, and some are even beneficial to man's purposes. They are one of the most important biological and mechanical factors in soil building. Those nematodes with which we are concerned here are parasites of plants. Some of these damage the roots, some the stems, some the leaves, and some the seeds of many agricultural and horticultural plants.

Recognition characters and biology. Nematodes are unsegmented roundworms quite different from all other forms of life. Plant parasites may be less than 0.4 mm long when fully grown, and few ever exceed 8 millimeters. In most, the body is very slender and is tapered at both ends.

There is a tough cuticle, secreted from underlying tissue, which may be smooth, striated, bossed, or ornamented with spines. The body has longtidinal muscle fibers only. These fibers produce flexing movements, but no elongation or contraction. When seen under a microscope in clear water, the movements seem to produce only a useless thrashing about. However, in the presence of plant debris or soil particles, the flexing of the body can produce a forward movement.

Both sexes exist in nematodes, though some females can produce eggs in the absence of males. The tiny larvae which hatch from the eggs are shaped like adults. They grow rapidly, shedding their cuticle several times before reaching maturity. Under favorable conditions, growth may require a few days to a few weeks, depending on the species. Some will repeat the reproductive cycles as long as temperature and moisture conditions are favorable and as long as the host plant lives. Some will leave dead host plants to enter the soil; some will stay in the dead plant tissue and may remain dormant for several years.

Feeding methods vary from one type of parasite to another. Some enter the plant cells and eat the cell contents. Some feed by means of stylets that puncture the cell walls and, like hypodermic needles, permit the nematodes to suck out the cell juices. The stylet punctures permit penetration by disease-causing bacteria. Parasitic fungi enter the plant through the holes made by the nematodes that feed within the cells.

A single root-knot nematode female may produce 500 to 1,000 eggs; yet few of the larvae which hatch from them will ever live to reach maturity and to reproduce. Nematode parasites of plants have many enemies in the soil. They are captured readily and devoured by other soil animals, such as insects and predatory, free-living nematodes. Even certain soil fungi are capable of trapping living plants; thus, nematodes must compete with fungi for food. Since nematode movement is more or less random, and since the nematodes are very small, they must be very close to a food source to find it. Those that penetrate some forms of "resistant" plants are effectively trapped, for their activity is limited and they are seldom able to reproduce.

Exercises (A39):

1. Most mature nematodes are quite ____________, requiring ________________ to be seen.
2. Both sexes exist in nematodes, though some females can produce ____________ in the absence of ______________.
3. When nematodes are seen under microscopes in clear water, the movements seem to produce only a useless ____________ ____________.

A40. Complete given statements concerning the damages caused by the root-and top-growth-attacking nematodes.

The nematodes that parasitize plants may be categorized arbitrarily by the part of the plant they parasitize and by the way they attack. Some of the individual species attack many types of plants, the common garden nematode *Heterodera schachtii* being found on over 1,000 varieties. The evidence of nematode infestations may be indicated by stunted growth occurring in grassed areas, flower beds, small gardens, and ornamental shrubs. Whenever you find such conditions, you should consider attack by nematodes as a possible cause.

Root-Attacking Nematodes. Nematodes that attack roots may be separated into four groups based upon the part of the root in which they infest: sedentary parasites, endoparasitic, semiendoparasitic, and ectoparasitic.

Sedentary parasites. In this group, females become fixed in one position, where they feed until death. Unlike most others, these females do not retain their wormlike appearance but become swollen. The important types of sedentary parasite nematodes are as follows:

a. Cyst nematodes. The females of this group of 12 to 15 species develop into brown, pear-shaped cysts, which contain and protect viable eggs up to 10 years. Plants that they attack appear stunted, have yellow leaves, and have a very fine, hairy looking root system. Hosts include some truck crops, clovers, and ornamentals and are subject to U.S. and foreign quarantines.

b. Root-knot nematodes. There are eight species in this group in which the females become globular, but do not form cysts. They usually may be found in swollen knots in the root system. These knots typify the group, which attacks 1,800 species of plants. Plants included are nursery stock, ornamentals, and grasses.

Endoparasitic nematodes. Eggs are deposited in lesions within roots where the larvae feed. All stages may be found free in the soil.

a. Burrowing nematodes. One species parasitizes several hundred species of plants, which include woody ornamentals. It is a serious pest of citrus, causing tip dieback, sparse growth, and spreading decline. It is currently under quarantine in Florida.

b. Meadow or lesion nematodes. There are 20 species of this group, which are found in small lesions in roots or free in the soil. Hosts appear necrotic and unthrifty, and include fruit trees, trees, ornamentals, and nursery stock.

Semiendoparasitic nematodes. These nematodes feed both externally and within the roots of plants.

a. Spiral nematodes. There are about 12 described species of this group. They are usually found free in the soil around roots. Attacked plants demonstrate chlorosis, stunting, and sometimes sparse growth. Spiral nematodes damage ornamentals, including roses and boxwoods, and lawn grasses.

b. Lance nematodes. There are two species of lance nematodes whose damage looks like that caused by spiral nematodes on the same hosts. However, these are also pests on some lawn grasses.

Migrant or ectoparasitic nematodes. These nematodes feed at the tips and along the surface of roots. They sometimes insert part of their bodies into the root tissue. This damage results in chlorosis and stunting due to sparse root systems having short, stubby, lateral roots.

a. Sting nematodes. There are two sting nematodes, both of which are parasites of ornamentals and lawn grasses. They normally are found in the light, sandy soils of the coastal plains.

b. Stubby root nematodes. Only one of 15 species of this group is known to be parasitic. It is of widespread distribution in the United States and affects a variety of plants, including a large number of grasses and truck crops.

c. Dagger and needle nematodes. Two important species in this group are primarily parasites of perennials. One causes the general decline of boxwoods and roses. Dagger nematodes have worldwide distribution. Little is known about the prevalence of the needle nematodes, but they have been collected in Europe, the Pacific Northwest, and several species in the Southeast.

d. Stunt nematodes. This group is comprised of parasites of many plants. One species is an important pest of strawberries, tobacco, and ornamentals. Stunt nematodes have been found in the East, Southeast, and a Southwestern State.

e. Ring nematodes. There are about 20 known species of ring nematodes. Evidence indicates that they are important parasites of trees and other woody perennials, but they also are found associated with the roots of grasses and many other plants. They live in many parts of the world.

Top-Growth-Attacking Nematodes. Nematodes attacking the top growth of vegetation may be separated into three groups, based upon the part of the plant that they attack. These groups are called the bud and leaf nematodes, stem and bulb nematodes, and seed gall nematodes.

Bud and leaf nematodes. There are a dozen or so species in this group that are important pests. Some feed in the developing buds and, subsequently, in the very young leaves. They cause leaf crimping, deformation, and plant unproductivity. Strawberries, alfalfa, and rice may be hosts to these parasites. Several species attack primarily the leaf parenchyma, where progressively darkening, angular spots may lead to eventual defoliation. This occurs on chrysanthemum, aster, dahlia, zinnia, and other plants raised for their flowers. Distribution of this group is widespread. These nematodes that feed within the leaf will move from leaf to leaf in films of water from rain or dew.

Stem and bulb nematodes. A number of species of nematodes invade the stem and bulb parts of such hosts as alfalfa, clover, and certain grasses, as well as such ornamental bulbs as iris, tulips, and narcissus. They invade the parenchymatous tissue and injure the plant with their salivary secretions. Distortion, hypertrophy, necrosis, secondary infection, or general unthriftyness result. Members of the group are found throughout the world.

Seedgall nematodes. Two of 11 species of this group are important economically in the United States. They develop in the growing part of wheat, lawn grass, and grasses grown for commercial seed. They complete development within a resistant gall in the seed. Seeds are destroyed or contaminated. Animals feeding on the infested seeds are poisoned. The wheat nematode is found primarily in the Eastern States, while the bentgrass nematode occurs in greatest numbers in the Northwestern States.

Exercises (A40):

1. The four groups of root-attacking nematodes are ______, ______, ______, and ______.
2. In the sedentary parasites group, the females become ______ in ______ position where they feed until ______.
3. Plants that cyst nematodes attack appear ______ ______, have ______ leaves, and have a very ______, hairy looking ______ system.
4. Root-knot nematodes attack ______ species of plants.
5. Endoparasitic nematodes eggs are deposited in ______ within ______ where the ______ feed.
6. Burrowing nematodes are a serious pest of ______ ______, causing ______ ______, ______ growth, and ______ decline.
7. Meadow or lesion nematodes are found in small ______ in ______ or free in the ______.
8. Semiendoparasitic nematodes feed both ______ ______ and within the ______ of ______.
9. Spiral nematodes are usually found ______ in the ______ around ______.
10. Lance nematode damage looks like that done by ______ nematodes on the same hosts.
11. Migrant or ectoparasitic nematodes feed at the ______ and along the surface of ______.
12. Bud and leaf nematodes feed in the developing ______ and, subsequently, in the very ______ leaves, causing leaf ______, ______ ______ and plant ______.
13. Stem and bulb nematodes invade the ______ tissue and injure the ______ with their ______ secretions.
14. Seedgall nematodes complete development within a resistant ______ in the seed. Animals feeding on the infested seeds are ______.

A41. State the survey and control procedures for nematodes.

Unthriftiness, stunting, malformation, chlorosis, or death of plants may be caused by nematodes, insects, nutritional deficiencies, drought, and other conditions. It is, therefore, necessary to establish the presence of nematodes and to identify them in order to take the right corrective measures.

Survey. Collect soil and root samples as follows and forward them to the appropriate command entomologist after you have received approval from the local agricultural department. If the plant in question is small and is expendable, place its roots and most of the soil attached to them in a 1-quart polyethylene bag or freeze bag. Attach a label with the names of the installation, collector, host plant, and locality written on it in indelible pencil or ink. close the bag with a rubber band and put the bag in a suitable mailing box. Wrap the box and place the agricultural permit label on the box. In the case of a large plant, get a sample of its roots and associated soil. Bag and label this similarly. If turf is affected, include a 2-inch square plug 6 inches deep from the margin of the infested area.

Preventive Control. Nematodes brought into installations in soil and plants will adversely affect plants to which they spread. It is, therefore, a must that everyone responsible for grounds maintenance take the few preventive measures necessary to avoid the spread of plant parasitic nematodes.

Nematode-free stock. All nursery stock to be used on military installations should be procured certified free of plant parasitic nematodes or otherwise be certifiable under local restrictions.

Equipment steam cleaned. Incoming and outgoing equipment or any other facility on which there may be soil attached should be thoroughly steam cleaned or at least washed off, and the equipment allowed to dry. Cleaning off all soil and exposing the equipment to direct sunlight is sufficient in areas where cyst nematodes are not a problem.

Quarantines. Several Federal quarantines have been established to prevent the further spread of certain nematodes. Some states also have local restrictions. Those responsible for the dispatch of plants, plant products, soil, tracked vehicles, or earth-moving equipment to or from military installations should familiarize themselves with the quarantines applicable within their areas of operation.

Chemical Control. all nematocides are highly toxic to animals. Thus, you must take precautionary measures to avoid inhalation and skin contact.

One of the most important considerations in selecting a nematocide is its phytotoxicity. A few important plant nematodes infest aboveground parts of plants. You can use penetrating sprays of nonphytotoxic nematocides on these. However, most of our important plant nematodes are inhabitants of the soil. You can use nematocides toxic to living plants in seedbed or field preplant sterilization. In order for chemicals to reach the nematodes in the soil, you must use either vaporized or water-dispersed nematocides.

Injected liquids that vaporize. The most successful control has been attained by soil fumigation with vapors liberated by volatile liquids that are injected into the soil at closely spaced intervals. Diffusion through the soil, and subsequent effectiveness, is largely dependent upon soil porosity, moisture, and temperature.

The area must be prepared and leveled as for planting. Soil moisture should not be unusually high or low, and the temperature should be between 60° and 80° F (15.68° and 26.88° C).

Inject volatile soil fumigants into the soil at depths of 8 to 10 inches to facilitate proper vaporization and dispersal. You give this treatment in small plots with specialized hand equipment and 1-foot grid pattern. When you calibrate the application to the manufacturer's recommended dosage rate, you make the injections at the points of grid line intersection. Tamp the holes closed. Normally, a waiting period of 2 to 3 weeks before planting is required with most nematocides.

Tractor-drawn application equipment is available for larger areas. Its principle is essentially the same, except that furrows are dug, treated, and covered by the equipment.

The use of methyl bromide requires a different procedure and different equipment. The area must be leveled, as prepared for planting, and irrigated to bring the moisture to about 60 percent of capacity. Distribute buckets or similar supports over the area. Also put out shallow pans to receive the plastic applicator hose from the methyl bromide container. Securely fasten a hose directly over each pan, the numbers of which depend upon the manufacturer's dosage recommendation. Lead the other ends of the hoses outside the area to be treated. Then, drape a plastic tarpaulin, free from holes, over the supports. Seal its edges thoroughly with a 6-inch border of soil. Attach containers of liquid methyl bromide under pressure to special couplings on the outer end of the plastic hoses. When you puncture these containers, the methy bromide flows into the pans and becomes a very penetrating gas.

Water-dispersed drenches. The development of effective nematocides that are nontoxic to growing plants has stimulated increased use of water-dispersed drenches for the control of nematodes in turf and a wide variety of ornamentals. Areas to be so treated must be watered, but not saturated. Measure the diseased zone and a 6-foot strip of healthy looking turf around it. Calculate the dosage in accordance with manufacturer's recommendations. Make the proper dilution of the emulsion concentrate with water. Disperse it by hand sprinklers or with power equipment. In the latter case, run a test with water only in order to attain accurate distribution. Following treatment, irrigate the area with 2 inches of water. Plantings or a single plant may be treated similarly. You can use a metal rod to open holes in the soil within the root area 15 to 25 inches deep. A small earth dam made around the base of the planting or plant will contain the water required following treatment.

Exercises (A41):

1. List in sequence the steps that you should take to confirm suspicions of nematode damabe to small and expendable plants.

2. What actions can you take to preclude the spread of plant parasitic nematodes? Answers may be listed in any order.

3. State the type and describe the method of treatment for controlling nematodes when you are going to use hand equipment and phytotoxic nematocides.
   a. Type.

   b. Method.

A42. Identify as true or false given statements pertaining to snails and slugs.

Importance of Terrestrial Snails and Slugs. In some parts of the world, snails serve as food for man and are cultivated for this use. In many other places, some species of terrestrial snails and slugs are very serious economic pests.

While most species native to the United States are solitary in habit and do very little damage, some introduced species require control. Because these imported species arrived in the United States without their parasites and predators and because they are colonial in nature, they can build enormous populations in limited areas. These highly destructive snails require continuing control and constant vigilance to prevent further introduction and spread.

Many species not native to the United States are prohibited entry by Federal quarantine. Military equipment and vehicles returning to the United States from overseas operational or storage areas must pass quarantine inspection for living snails. When live snails are found during quarantine, inspection, fumigation, saltwater washdown, or steam cleaning are required. These operations are time consuming and costly wherever performed, but they are considerably more expensive at United States ports than at overseas ports before shipment.

Snails and slugs are of economic importance for three reasons: (1) Some serve as food for people. (2) Many function to maintain a balance of nature in their native areas. (3) Others can be very destructive, particularly when introduced into new areas.

Human food. Some helicine snails have served as food since early times. They are highly nutritious and are considered to be delicacies. For a number of years, over a million pounds of European snails per year were imported into the United States.

The giant African land snail is an important food source in its native areas, and in some locations the snail forms the largest single item of animal protein in the human diet. This snail is not considered a delicacy as are the European helicines, and many people consider it to be inedible. In its native area, the African snail is highly beneficial, but in those areas to which it has been exported, it is a serious economic pest.

Natural controls. Snails and slugs in their native habitats are members of natural communities in which their populations are controlled by ecological forces. These natural population controls include natural enemies (predators and parasites), unfavorable climate, and an inability to overcome competition for food and shelter. Snails are an integral part of this ecological balance.

Economic pests. When a snail or slug species is introduced into a new area, it usually leaves its predators and parasites behind. If these important checks are not present, and if other environmental factors are favorable, the species can realize its full population potential. If this potential is high, only a short period of unchecked reproduction will cause the population to erupt. The invaders then proceed to consume certain plants in great quantity, destroying food and shelter of other organisms. Reduction in the abundance of these native species results, followed in turn by their predators and parasites. The whole organization of a community may in this way be completely disrupted by such an immigration. This can cause many beneficial plants and animals to disappear permanently from the area. When the introduced species has exhausted its food supply, it may emigrate in many directions to other communities. Thus, the indirect economic import of introduced species actually may be far greater than the more obvious economic importance.

Of the approximately 725 species of terrestrial snails and 40 species of slugs now recognized in the United States (exclusive of Alaska and Hawaii), 44 snails and 11 slugs have been introduced. Within the areas into which they have been introduced, the distribution for any species tends to be spotty. Population densities are influenced by depths and types of soils, by climatic conditions, by availability of food, and by the intensity with which land is cultivated. *Achatina* has become established in Hawaii. Though it has been intercepted during quarantine inspections at California ports, *Achatina* is not known to have become established there. *Theba pisana* was introduced into California in the early 1920's, and had became well established before extensive control programs brought about its eradication. It was introduced into South Carolina in 1956 via military cargo returned from North Africa but was eradicated before it became firmly established. *Helix asperta* and *Otala lactea* have become well established in California. Considerable time, energy, and expense have been devoting to combating them.

Where it has been introduced *Achatina fulica* feeds on a wide variety of plants. As a group, grasses are nearly immune to attack. Even the larger "grasses," such as rice, sugar cane, and corn are fed upon only when no other foods are available, but many weeds are eaten. Food preferences seem to vary from place to place where this snail has been introduced, but throughout its present area the giant African land snail is highly destructive to many plants. Most fruits and vegetables raised by man are attacked, and such other economically important plants as tobacco, cotton, rubber, and young teak trees are eaten as are many ornamental plants. The extent of damage that might be done by this snail if introduced into the continental United States is unknown.

Of the several economically important Mediterranean snails, *Theba pisana* is considered the most destructive. It has a voracious appetite. When young, it will consume three to five times its own weight of vegetation each day, and it will double its size in the first week and again in the second. Some of the Mediterranean snails are stem feeders, but *Theba pisana,* though it eats stems of some legumes, feeds primarily on leaves. Many snails eat straw, manure, and dead plants and animals, but *Theba pisana* will eat these only if foliage is not available. It feeds on weeds, particularly on thistle and other composites. It destroys alfalfa and a wide variety of legumes and has a strong propensity for citrus. It has demonstrated its ability to become a serious economic pest where introduced, as have its near relatives.

Exercises (A42):

1. Place the letter "T" before the correct statement.

___ a. In some parts of the world, snails serve as food for man and are cultivated for this use.

___ b. When snails are introduced into new areas, they may become serious economic pests.

___ c. For many years over a million pounds of snails per year were imported into the United States.
___ d. The giant African land snail is an important food source in its native area.
___ e. The number of native snails is controlled, to a large extent, by natural enemies and climate.
___ f. Many snails eat straw, manure, and dead plants and animals; however, *Theba psiana* will eat these only if foliage is not available.
___ g. *Achatina* have become established in California.

2. Correct any incorrect statements.

A43. Associate the names of the terrestrial snail and slug families with given descriptions, and complete statements concerning the biology of snails found in military cargoes.

Terrestrial snails and slugs are gastropod mollusks. Almost all of those of economic importance belong to the order Pulmonata. The shell, if present, is basically a simple spiral or helix and is composed primarily of calcium carbonate. There are no gills, but rather an air-breathing lung opening by a contractile pore.

Slug Families. There are four families of slugs found in the United States.

Families Veronicellidae, Arionidae, and Limacide. These slugs are all either completely without shells or have only internal vestigial shells. Some of the more important genera are: *Veronicella, Arion, Milax, Deroceras,* and *Limax.*

Family Testacelliadae. Slugs in this family have small, rudimentary shells near the posterior ends of their bodies. A single introduced species, *testacella haliotidea* spends considerable time in the ground, where it feeds chiefly on earthworms.

Snail Families. There are five families of snails found in the United States.

Family zonitidae. Snails of this family are almost worldwide in distribution. The shell is usually umbilicate, and has a low spire that gives it a rather discoidal outline. The lip is thin and not reflected (not turned back). Some of the species native to North America are of little economic importance, but three introduced species of the genus *Oxychilus* are pests. Some of these not only feed on young plants, but are predatory and carnivorous and feed on other snails.

Family Bradybaenidae. the shell of this family is wider than high, thin, narrowly umbilicate, with a rather depressed spire. The lip is reflected. The species *Bradybaena similaris* is a pest of horticulture and floriculture whenever introduced in areas of suitable climate, such as Hawaii.

Family Achatinidae. Snails of this family have shells that vary in shape from oval to long and thin. All are longer than wide. These snails are distributed widely, and many are quite destructive. Two species of *Cecilioides* have been introduced into the United States. They usually stay in the soil, and are moved with roots of plants. Two species of *Opeas* have been introduced from the Orient and tropical America. Four species of Lamellaxis have been introduced into the United States from tropical areas of both the old and new world. *Subulina octona* has been introduced from the Tropics, and *Rumina decollata* from the Mediterranean. The most destructive pest in this family is the giant African land snail *Achatina fulica,* which has spread widely throughout the Central and Southwestern Pacific. This snail, which can reach an overall length of nearly 1 foot, has been intercepted at United States ports but has not become established in North America.

Family Helicellidae. Shells of these snails are all either umbilicate or perforate, with shapes that vary from long and narrow to broad and flat. This is a large family, with snails of several species introduced into North America from Europe, Western Asia, and North Africa. Some of these are not only very destructive, but are readily transported because they leave the ground in hot weather and crawl onto surfaces where they seal the shell against drying. Several species of *Cochlicella Helicella, Monacha,* and *Hygromia* have been introduced into the United States.

Family Helicidae. The shells usually are banded, wider than high, loosely coiled, with the central column hollow or umbilicate. Adults often have the umbilicus closed over by an extension of the lip. This family is of European origin. It contains the edible snails. Two species of Otala are cultivated as food. Various species of economic importance in the genera *Helix, Cepaea, Otala,* and *Theba* have been introduced into the United States, and *Helicigona* elsewhere into North America.

Snails in Military Cargoes. The land snails that quarantine officials find most commonly on military cargoes belong to three genera: *Theba, Helicella,* and *Cochlicella.* The habits of these snails are typified by *Theba pisana,* the white garden snail. In the autumn and winter rainy season of plant growth, the snails actively feed and reproduce. They are reported to reproduce by self-fertilization, although mating has been observed. Prior to egg-laying, the snail prepares a nest by loosening the soil with its mouthparts and moving it to the rear by undulating movements of the foot. After the egg mass is deposited at about a 1-inch depth, the burrow is filled with soil. After about a week in the soil, the eggs hatch, and the small snails move to the undersides of leaves to feed. With the onset of the hot, dry, summer months, they cease to feed and seek surfaces above the hot ground to aestivate (pass the summer in a dormant state). In search of suitable sites, they often follow the slime trails of other snails. Hundreds of aestivating snails may be found covering a small thorn bush or a signpost. The secreted mucous not only seals the shell and prevents drying, but also glues the snail to the surface on which it aestivates. In this condition, the snails can withstand long periods of dryness, and are unharmed by temperatures of up of 130° F (54.88° C), for short periods. In seeking sites for aestivation, the snails invade crates of military supplies, and in their dormant state, they can be shipped considerable distances before rain, fog, or other moisture reactivates them.

Exercises (A43):

1. Match column A with column B.

Column A

Descriptive Statements

___ 1. Snails of this family vary in shape from oval to long and thin.

___ 2. The shell of this snail is usually umbilicate and has a low spire that gives it a rather discoidal outline.

___ 3. These slugs are all either completely without shells or have only internal vestigial shells.

___ 4. Shells of these snails are all either umbilicate or perforated, with shapes that vary from long and narrow to broad and flat.

___ 5. Slugs in this family have small, rudimentary shells near the posterior end of their bodies.

___ 6. A snail in this family will have a shell wider than high, thin, narrowly umbilicate, with a rather depressed spire.

___ 7. The shells are banded, wider than high, loosely coiled, with the central column hollow or umbilicate.

Column B

Family of Snails and Slugs

a. Veronicellidae.
b. Testacelliadae.
c. Zonitidae.
d. Bradybaenidae.
e. Achatinidae.
f. Helicellidae.
g. Helicidae.

2. In hot months, snails seek surfaces ____________ the ground.
3. Most snails pass the summer in a dormant state called ________________ .
4. The *Theba pisana* reproduces by ____________ .

A44. Complete given the statements concerning snail and slug inspection.

Inspection for Snails and Slugs. Inspections for terrestrial snails and slugs have two purposes: horticultural and quarantine.

Horticultural inspection. To inspect for snails and slugs in gardens, greenhouses, and other horticultural areas, you must actually search for the pests. Where you find plant damage but do not see slugs or snails, you should inspect at night or early in the morning after a rain. You can use attractants, such as metaldehyde or diced apples or other fruit, to draw out the snails and slugs. When you can't inspect at night or early in the morning, place baits on sheets of wrapping paper so that you can see the slime trails.

Quarantine inspection. Basically, a quarantine inspection for terrestrial snails is a search for the snails on materials shipped on containers, and on tracked and wheeled vehicles. It is important to inspect small and obscure spaces where only very small snails may have been able to find space. Thorough inspection of cargo and cargo spaces on arrival at a United States port generally is more difficult and more time consuming than inspection at the point of origin of the cargo.

A thorough inspection should be made of all military material and personal household effects of military and civilian personnel before they are moved from a known snail area to any destination. Because of the tendency of snails to hide in crevices or to crawl into holes or other openings. You must inspect the interior as well as the exterior of containers when you see likely entry holes. The smaller snails resemble ordinary pebbles in color markings as well as size; therefore, you could overlook a significant infestation on a superficial inspection of contaminated articles. CONEX boxes, particularly when they have been in contact with the soil, offer a number of havens for snails—the bottom runners (some of which are hollow), the lift hook slots, and the occasional rust holes in the more weathered boxes. You should examine all sides of each likely item. Note in particular any cracks, crevices, or other areas not readily observable. Forklifts frequently will be required for inspection of bottoms of boxes, crates, and the heavier articles. Occasionally, the presence of snails may be indicated by a faint slime trail. Steel cylinders present good hiding places for snails aestivating under the screw cap and adhering to the pallets on which cylinders are often fastened. Pipes of all types are especially attractive to snails since caps or plugs are seldom feasible. In the case of halftracks, cranes, and other heavy equipment, steam or water-jet cleaning is recommended in lieu of or in addition to examination. When you examine the ships before they are loaded, give attention to the bottom of holds and around the sides of ledges. Hold bulkheads near the engine room, being warmer, are favored snail sites. Snail-free cargo should never be loaded until holds have been inspected thoroughly and found or made snail-free.

Exercises (A44):

1. The two purposes of snail and slug inspections are ________________ and ________________ .
2. To determine slime trails, baits may be placed on ________________ of ________________ .
3. The two best times to inspect for snails in a garden are at night or ____________ ____________ ________ ____________ after ____________ ____________ .
4. Cargo inspection is easier at the point of ________ than at the point of ____________ .
5. Occasionally, the presence of snails may be indicated by a faint ____________ trail.

A45. Identify as true or false given statements pertaining to the control of snails and slugs; correct any false statements.

The five categories of snail control are physical control, cultural control, biological control, chemical control, and decontamination.

Physical Control. You can search actively for the pests and handpick or crush them as you find them, but physical control may also include the following practices to prevent military supplies, engineering equipment, and transportation equipment from becoming infested with snails and slugs:

a. Incoming supplies should be stored in warehouses. Land snails normally do not enter buildings to aestivate; therefore, inclosed structures provide the greatest protection against infestation.

b. If warehouses are not available for storage, paved storage areas can be used. However, these areas must be protected by sound, aggressive, and continuous chemical and cultural control programs.

c. Only snail-free supplies should be stored in warehouses or in snail-free storage areas. Infested cargo should never be mixed with snail-free cargo in storage or in transit.

d. Equipment and materials (forklifts, tractor trailers, railcars, pallets, dunnage, and tarpaulins) used in the storage or transportation of noninfested supplies must be snail-free. Equipment not in use should be returned to snail-free areas. Equipment used to handle or transport snail-infested supplies should not be used to transport snail-free cargo unless the equipment has been fumigated.

e. Snail-free storage areas should be established at those installations where large quantities of supplies are stored in open areas.

f. To prevent the contamination of commercial or military carriers during the movement of supplies from one installation to another, only snail-free cargo should be shipped.

g. Adequate procedures must be established to prevent snail "stowaways" in personal household effects of military and civilian personnel. Lawn furniture, sporting goods (boats, motors, etc.), bicycles, motor scooters, utility trailers, and other personal effects that are allowed to remain outdoors must be fumigated before they are packed for shipment.

h. Equipment used in grounds maintenance work should not be stored or left idle in snail-infested areas. This equipment should be cleaned and returned to the equipment storage area at the end of each day.

i. CONEX transporters should be stored in warehouses or in snail-free areas when not in use. They should not be stored or allowed to remain on the ground. Snail-infested supplies or household effects should never be packed in CONEX transporters for shipment.

Cultural Control. Cultural control involves destroying habitats or hiding places by clearing underbrush and by eliminating refuse piles, loose boards, and stones. The mowing of grasses and weeds will help keep some species from increasing in population. Cultivation of the soil during the period of snail activity and breeding season will destroy many snails and their eggs. Plowing or turning the soil is preferred, but discing and cultipacking is helpful in areas where plowing is not practical, such as ammunition storage areas, golf courses, fence rows, and airfields. Plowing and the seeding of small grain to reduce erosion is recommended every 12 months. Burning heavily infested areas has been employed successfully in eliminating aestivating land snails in California and North Africa.

Biological Control. The biological method for snail control is based on the natural balance between mollusks and their enemies. This balance is shifted in favor of the introduced species when they become pests, but it can be shifted in the opposite direction by importing their foreign predators or by conserving and augmenting natural, established predators. In introducing predators, extreme caution must be observed because of the possibility that they may become more serious pests than their prey. Any introduction of foreign species can be made only after careful study and approval by the U.S. Department of Agriculture. Many mammals, birds, reptiles, amphibians, rodents, and insects have been recorded as occasional predators of snails and slugs. In the continental United States, however, none offer effective and practical means of control of introduced species of snails and slugs, except for the limited use of turkeys, ducks, and chickens. Carnivorous snails attack some economically important pest snails and can greatly reduce the pest population at times. Dependence upon predators requires acceptance of the pest population level sufficiently high to maintain the predator population.

Chemical Control This kind of control involves the use of contact sprays and paints, irritating powders, poison baits, and deterrents. Since land snails must have lime to consolidate their shells and must actively search for it if it is not readily available to them, you can paint or spray objects with 1 percent solution of calcium arsenate mixed with lime water. This mixture serves as a lure and as a poison. Sprays of Bordeaux mixture, kerosene emulsion, chlordane, lindane, pyrethrum, DDT, soap solutions, and lime sulfurs are good repellents, but they are not effective in eliminating the snails or slugs.

Sodium pentachlorophenate is a contact poison that effectively controls land snails and slugs for a period of several days to several weeks. This material should be used as barrier to surround materials to be protected from snail contamination. Apply it at the rate of 40 pounds per acre. Frequency of application depends upon soil conditions, rainfall, and the density of the snail population. Protective barrier rings of coal tar, soot, ash, lime, salt, and other substances often are used to keep snails and slugs from valuable plants, gardens, and other areas where they could cause damage. Since some of these materials can kill vegetation or injure the soil, you must use them with caution. Lime, salt, soot, ash, and similar substances act as dehydrators, causing slugs and snails to secrete slime so copiously that they dry out and die. These materials have limited effectiveness during the wet seasons of the year and must not be relied on as "cure-all" materials. Metaldehyde has been found to be one of the most important chemical weapons against land snails and slugs, but it is not always completely effective against all species.

Baits containing metaldehyde have been used successfully in reducing most snail and slug populations. The success of poison baits in snail control depends upon the timing of the application. Apply baits when the snails are active and feeding. You can get baits commercially in meal or pellet form with or without calcium arsenate and containing metaldehyde. Prepare the bait by the following formula:

10 ounces metaldehyde
20 ounces calcium arsenate or sodium fluosilicate
20 pounds wheat bran or cornmeal

Add enough water to moisten the bait. Apply the bait at the rate of 1 pound per 1,000 square feet (40-50 pounds per acre).

In general, baits are more effective in areas where vegetation is scant. The use of metaldehyde sprays is not recommended. When handled as recommended, it can be used safely as a pesticide. When used in combination with an arsenical, you must also observe all use restrictions and precautions specific to this type of toxicant.

Decontamination. High-pressure washdown is used to remove snails as well as encrusting dirt from military vehicles. Tracked ramps are used to elevate the vehicles sufficiently to permit hose handlers to clean the undersides thoroughly. Cleaned and reinspected vehicles are parked only on snail-free hardstands to await ship loading. When washdown is needed at points of arrival after shipment, sea water is used and is drained only into bodies of salt water.

Snail-infested materials that cannot be decontaminated by washdown are fumigated.

Exercises (A45):

1. Place the letter "T" before each correct statement.

___ a. Land snails normally enter buildings to aestivate.
___ b. CONEX transporters should be stored in warehouses or in snail-free areas.
___ c. Infested cargo should never be mixed with snail-free cargo in storage.
___ d. The mowing of grass and weeds will keep some species of snails from increasing in population.
___ e. The introduction of predators is a biological method of controlling snails.
___ f. Sodium pentachlorophenate is a good repellant for snails.
___ g. Protective barrier rings of coal tar, soot, ash, lime, and salt are used to keep snails and slugs from valuable plants.
___ h. Snail-infested materials that cannot be decontaminated by washdowns are fumigated.

2. Correct any false statements.

A46. State the characteristics of plant fungi.

Characteristics of Plant Fungi. Fungi are small, generally microscopic, plants lacking chlorophyll and conductive tissues. Most of the 100,000 fungus species known are strictly saprophytic (living on dead organic matter which they help decompose). About 50 species cause diseases in man and animals. More than 8000 species of fungi can cause diseases in plants.

Fungi can enter plant tissues through wounds, through natural openings, and/or directly through the cuticle and the epidermis. Once inside the plant, the fungi remove nutrients from the plant and use them for their own growth and production.

The mere removal of nutrients that the plant cells would normally use for their own processes is sometimes sufficient cause for development of an unhealthy condition in the host cells. This condition leads to localized or generalized disease symptoms on the plant.

Exercises (A46):

1. Fungi are small, generally ________________, plants lacking ____________ and ____________ tissues.
2. More than ____________ species of fungi can cause diseases in plants.
3. Fungi enter plant tissues through ____________, through ______________ ____________, and/or directly through the ______________ and the ______________.
4. Once inside the plant, fungi remove ____________ from the plant and use them for their own ____________________ and ________________.

A47. Relate symptoms of important plant diseases to the names of the diseases.

Plant Diseases Caused by Fungi. Diseases of plants caused by fungi are so numerous that it is impossible to discuss each of them within this text. Three of the most common plant diseases caused by fungi are covered because they occur throughout the world and affect many varieties of plants.

Damping off (root rot). Damping-off disease of seedlings occurs all over the world in valleys and forest soils, in tropical and temperate climates, and in almost every greenhouse.

Older plants are seldom killed when infected with the damping-off pathogen, but they develop stem lesions or root rots, their growth may be retarded considerably, and their yields may be reduced drastically.

Powdery mildew. Powdery mildews are very common diseases on a great many plants, including grasses, vegetables, ornamentals, shrubs, and trees, particularly in arid and semiarid environments. Powdery mildew of roses occurs everywhere in the world where roses are grown.

Powdery mildew is one of the most important diseases of roses, both in the garden and in the greenhouse. The disease appears on roses year after year and causes reduced flower production and weakening of the plant by attacking the buds, young leaves, and growing tips of the plants.

Here are the symptoms: On the young leaves the disease appears at first as slightly raised, blisterlike areas that soon become covered with a grayish-white, powdery fungus growth. As the leaves expand, they become curled and distorted.

On older leaves, large white patches of fungus growth appears, but there is usually little distortion. Lesions on leaves may appear more or less discolored.

Dutch elm disease. Dutch elm disease owes its name to the fact that it was first described on elm in Holland in 1921. Since then the disease has spread throughout Europe, parts of Asia, and most of North America. In the United States the disease was first found in Ohio and in a few States of the East Coast as early as 1930; since then it has spread westward as far as Idaho and is expected to continue to spread. Dutch elm disease is the most destructive shade tree disease in the United States today. It affects all species of elm. The American elm, which is the most valuable native elm shade tree, is one of the most severely affected. The disease may kill branches and entire trees within a few weeks or a few years from the time of infection.

This disease is the result of an unusual partnership between a fungus and an insect. Although the fungus alone is responsible for the disease, the insect is the indispensable vector of the fungus, carrying the fungus spores from infected elm wood to healthy elm trees. The insects responsible for the spread of the disease are the European elm bark beetle (*Scolytus multistriatus*) and the native elm bark beetle *(Hylurgopinus rufipes).*

The first symptoms of the disease appear as sudden or prolonged wilting of the leaves of individual branches or of the entire tree. Wilted leaves frequently curl, first turn yellow, then brown, and finally fall of the tree earlier than normal. Most affected branches die immediately after defoliation. The disease usually appears first on one or several branches and then spreads to other portions of the tree. Such trees may die gradually branch by branch over a period of several years, or they may recover. Sometimes, however, entire trees suddenly develop disease symptoms and usually die within a few weeks. Usually trees that become infected in the spring or early summer die quickly, while those infected in late summer are much less seriously affected and may even recover.

Exercises (A47):

Match each statement in column B with the plant disease in column A. There may be more than one statement for each disease.

Column A	*Column B*
Plant Disease	*Statements*
___ 1. Damping off.	a. On young leaves it appears at first as slightly raised blisterlike areas.
___ 2. Powdery mildew.	b. It is one of the most important diseases of roses, attacking buds, leaves, and growing tips.
___ 3. Dutch elm.	c. The most destructive shade tree disease; causes branches to die immediately after defoliation.
	d. It occurs in valleys and forest soils, in tropical and temperate climates, and in almost every greenhouse.
	e. The first symptom of the disease appears as sudden or prolonged wilting of the leaves of individual branches or on the entire tree.

A48. Identify as true or false given statements pertaining to the control of fungus diseases of plants.

Control of Fungus Diseases of Plants. The endless variety and the complexity of the many fungus diseases of plants have led to the development of a correspondingly large number of approaches to their control. The particular characteristics in the life cycle of each fungus, its habitat preferences, and its performance under certain environmental conditions are some of the most important points to consider in attempting to control a plant disease caused by a fungus.

The use of treated seeds is always recommended and, for control of certain diseases, it is mandatory. Destruction of plant parts or refuse harboring the fungus spores, use of clean tools and containers, proper drainage of lawns and fields, and proper aeration of soil and plants are all very important practices in the control of most plant diseases caused by fungi.

The use of plant varieties that are resistant to certain parasites has found its greatest application in controlling such fungus diseases as rusts and wilts. The most effective method, however, and sometimes the only one available for controlling most of the fungus diseases of plants, is through application of chemical sprays or dusts on the plants, their seeds, or into the soil where the plants are to grow.

Most fungicides are used to prevent diseases on the aboveground parts of the plants and are applied on the foliage as sprays or dusts. Almost all of these are protectants, since they can only prevent fungi from causing infection but cannot stop an infection once it has started.

There are a number of fungicides which include many inorganic and organic compounds. The most common of these are elemental sulfur copper compounds (Bordeaux mixture, Cuprocide, Perenox), thiocarbamates (thiram, ferlam, nabam, maneb, zineb, ziram), and mercury compounds (tag, coromerc).

Exercises (A48):

1. Mark each of the following statements C (correct) or I (incorrect).

___ a. The particular characteristics in the life cycle of each fungus, its habitat preferences, and its performance under certain environmental conditions are some of the most important points to be considered in attempting to control a plant disease caused by a fungus.

___ b. The use of treated seeds is always recommended, and for control of certain diseases, it is mandatory.

___ c. The most effective method of controlling fungus diseases of plants is through application of chemical sprays or dust on the plant.

___ d. Most fungicides are used to correct diseases on the aboveground parts of plants.

2. Correct any incorrect statements.

Answers for Exercises

CHAPTER 1

Reference:

A01 - 1. c.
2. a.
3. f.
4. d.
5. e.
6. b.

A02 - 1. Undetected; someone sees the damage.
2. Scissors; cigarette burns; termites; rodents.
3. Burns.
4. Webbing clothes moths.
5. Existing infestation.
6. Clothing; thoroughly; presence; adults: larvae.
7. Hidden; seams; pockets; storage; cushions; sofas; chairs.

A03 - 1. Controls for fabric pests may be in the form of nonchemical or chemical and may be either preventive or corrective.
3. When safely using paradichlorobenzene crystals as a preventive control measure in clothing storage areas, the crystals should be distributed so that they are placed out of reach of children.
4. Placing clothing in a very cold environment for a couple of days is an effective corrective control of fabric pests, providing the pests are in the adult or larval stages.
6. Fumigation is an effective corrective control measure for fabric pests but must be accomplished only by personnel trained in fumigation.

A04 - 1. a, b, c, e, g, and h are true.
2. d—Change Southern to Northern.
f—Change white and grey to brown and black.
i—Change black to white.

A05 - 1. a, b, c, f, g, and i are true.
2. d - Change smaller to enlarged.
e - Remove the word "not."
h - Change fine to coarse.

A06 - 1. Snout.
2. Larvae; pupa; adult; feeds.
3. Fields; warehouses.
4. Bean.
5. Field.

A07 - 1. b.
2. a.
3. c.
4. a.
5. b.
6. c.

A08 - 1. a - Change four to six.
c - Change green to brown.
e - Change khapra to cigarette.

A09 - 1. a, b, and e are true.
2. Prompt; food.
3. Flashlight, vials, pillboxes; hand lens; samples.
4. Beans; hams; cereals; cheese.
5. Exterior; ends; stitched.
6. Date; origin; date; name.
7. Incubators; emerge; detected.

A10 - 1. Sanitation; palletizing; rotation; isolation; ventilation; packaging; insect proof construction.
2. Torn; repaired; clean; contamination; food.
3. Sanitation.
4. Cartons; bags; containers; floor.
5. Palletizing.
6. Long; time; one; two.
7. Rotation.
8. Remotely; stocks.
9. Isolation.
10. Opened; closed.
11. Ventilation.
12. Packaging.
13. Packaging.
14. Planned; constructed.
15. Insectproofing.

A11 - 1. Radiant.
2. Ultra-low volume.
3. Pyrethrins.
4. Aluminum phosphide.
5. Vacuum.
6. Lightly; heavily.
7. Fumigated; repacked.

CHAPTER 2

A12 - 1. a, c, d, f, h, and j are true.
2. b - Change 40 to 20.
e - Change "least" to "most."
g - Add "do not" before produce.
i - Change "alkaline" to "acid."
3. Mold; stain; wood-rotting.
4. Starches; sugars; gums; oils; cellulose; lignin.
5. Black; blues; browns; reds; yellows.
6. White rots; brown rots; water-conducting.
7. Ligno-cellulose; lignified.
8. Ligno-cellulose; lignin.
9. Cellulose; lignin; brownish.
10. Brown-rot.
11. Humidity; temperature; tube; filament.
12. Secrete; dissolve.

A13 - 1. a, b, c, d, f, g, h, i, and j are true.
2. e - Change "decrease" to "increase" and "extend" to "shorten."

A14 - 1. Termites are the most destructive insect pests.
2. Wood and other cellulose products, such as paper, cardboard, and fiberboard.

3. Termites are an important part of ecology in that they help microbial organisms in breaking down wood and other cellulose materials into humus.
4. To the point that the buildings have to be condemned.
5. Termites carry fungus spores from the soil on their bodies.

A15 - 1. F.
2. T.
3. F.
4. F.

A16 - 1. Wings; body shape.
2. Approximately equal; longer.
3. Wasp; slab sided.
4. white ants.

A17 - 1. c.
2. c.
3. c.
4. a.
5. c.
6. c.
7. c.
8. c.
9. b.
10. a.

A18 - 1. b, c, e, f, and g are true.
2. a - Delete the word "not."
d - Change "above" to "below"
h - Delete the word "not."

A19 - 1. Inspection; preventive control; corrective control.
2. Planning; construction.
3. Stumps; logs; boards; stakes; form lumber; wood scraps; grading; drainage; air ventilation; chemically.
4. Residual insecticide.
5. Wood preservative.
6. Coat; paint.
7. Above; outside.
8. Dusting; squirting; surface treatment; fumigation.
9. Trichlorobenzene.
10. Methyl chloride.

A20 - 1. a.
2. b.
3. c.
4. c.
5. b.
6. a.
7. c.
8. b.
9. b.
10. a.
11. a.
12. b.
13. b.
14. c.
15. b.
16. a.
17. a.
18. b.
19. a.
20. c.
21. a.
22. c.
23. a.
24. b.
25. a.
26. b.
27. a.
28. c.

A21 - 1. c.
2. c.
3. c.
4. a.
5. b.
6. c.
7. a.
8. b.
9. a.
10. a.

A22 - 1. a, c, e, and g are true.
2. b - Change "more" to "less."
d - Change "insect" to "fungus."
Change "fungus" to "insect."
f - Change "can be left in place" to "should be removed."

A23 - 1. Tunnel; excavate.
2. Soft.
3. Chlorinated; injected.
4. Dusts; carried.
5. Southern.
6. Eat; excavate.
7. Tunnels; dusted; powders.
8. Coat; paint.

CHAPTER 3

A24 - 1. c.
2. b.
3. a.

A25 - 1. b.
2. a.
3. c.

A26 - 1. C.
2. I. The bagworm is a caterpillar which lives in a silken cocoonlike bag to which is attached bits of leaves or stems from the host plant.
3. C.
4. I. Cutworms are smooth, plump caterpillars, gray or brownish, and 2.5 to 5.0 cm long when full grown.
5. C.

A27 - 1. E.
2. E.
3. E.
4. B.
5. J.
6. J.
7. J.

A28 - 1. b.
2. d.
3. a.
4. c.

A29 - 1. General defoliators.
2. Layers of the leaf.
3. Handpicking.
4. For the use intended.

A30 - 1. T.
2. T.
3. F.
4. T.
5. T.
6. T.

A31 - 1. Borers.
2. Tunneling under bark; wood.
3. Fine boring dust; larvae; tunnels.

4. Paper; burlap; attack.
5. Carbon disulfide; paradichlorobenzene; benzene hexachloride; tunnels; putty.

A32 - 1. a, b.
2. d.
3. a, i.
4. a, c.
5. a, h.
6. a, f.
7. a, e.
8. a, g.

A33 - 1. Wasps; midges
2. Stimulate; swellings; leaves; twigs; roots.
3. Galls; unsightly.
4. Carbaryl; night; morning.
5. Chambers, depressions; are; have been.

A34 - 1. C.
2. I.
3. I.
4. C.
5. C.
6. C.
7. C.
8. I.

A35 - 1. e.
2. i.
3. a.
4. f.
5. b.
6. k.
7. m.
8. g.
9. n.
10. c.
11. o.
12. l.
13. h.
14. j.
15. d.

A36 - 1. f.
2. c.
3. e.
4. a.
5. d.
6. b.

A37 - 1. C.
2. I; change "black" to "bright red."
3. C.
4. C.

A38 - 1. Fall; soil; sun; spring.
2. Three; two or three; hinge.
3. Half dozen; grubs.
4. Broken-up; four-mesh; screen.

A39 - 1. Small; magnification.
2. Eggs; males.
3. Thrashing about.

A40 - 1. Sedentary parasites; endoparasitic; semiendoparasitic; ectoparasitic.
2. Fixed; one; death.
3. Stunted; yellow; fine; root.
4. 1,800.
5. Lesions; roots; larvae.
6. Citrus; tip dieback; sparse; spreading.
7. Lesions; roots; soil.
8. Externally; roots; plants.
9. Free; soil; roots.
10. Spiral.
11. Tips; roots.
12. Bud; young; crimping; deformation; unproductivity.
13. Parenchymatous; plant; salivary.
14. gall; poisoned.

A41 - 1. a. Collect soil and root samples.
b. Get shipment approval from the local agricultural department.
c. Place the plant roots and most of the soil attached to them in a 1-quart polyethylene or freeze bag.
d. Make a label identifying the names of the installation, collector, host plant, and locality. Put the label in the bag.
e. Close the bag with a rubber band and put it in a mailing box.
f. Wrap the box and place the agricultural permit label on the box.
g. Forward the box to the appropriate command entomologist.
2. a. Become familiar with quarantines within your area of operations.
b. Insure that incoming and outgoing equipment or any other soiled facility is thoroughly steam cleaned or at least washed off and allowed to dry.
c. Insure that all nursery stock to be used on your installation are procured certified free of plant parasitic nematodes.

A41 - 3. a. Preplant soil sterilization.
b. Prepare the area by digging, leveling, and marking it off in a 1-foot grid pattern. Calibrate equipment and inject recommended volatile liquids at a depth of 8 to 10 inches and at each intersecting grid line point.

A42 - 1. a, b, c, d, e, and f are true.
2. g. Achatina have *not*.

A43 - 1. 1. e.
2. c.
3. a.
4. f.
5. b.
6. d.
7. g.
2. Above.
3. Aestivation.
4. Self-fertilization.

A44 - 1. Horticultural; quarantine.
2. Sheets; wrapping paper.
3. Early in the morning; a rain.
4. Origin; arrival.
5. Slime.

A45 - 1. b, c, d, e, g, and h are true.
2. a. after "normally" insert "do not."
f. Delete "repellant" and add "contact poison."

A46 - 1. Microscopic; chlorophyll; conductive.
2. 8,000.
3. Wounds; natural openings; cuticle; epidermis.
4. Nutrients; growth; reproduction.

A47 - 1. d.
2. a, b.
3. c, e.

A48 - 1. a. C.
b. C.
c. C.
d. I.
2. d. Delete "correct" and insert "prevent."

STOP - 1. MATCH ANSWER SHEET TO THIS EXERCISE NUMBER.
2. USE NUMBER 2 PENCIL ONLY.

EXTENSION COURSE INSTITUTE
VOLUME REVIEW EXERCISE
56650 06 21
COLLECTION, IDENTIFICATION, AND CONTROL OF IMPORTANCE ECONOMIC PESTS

Carefully read the following:

DO's:

1. Check the "course," "volume," and "form" numbers from the answer sheet address tab against the "VRE answer sheet identification number" in the righthand column of the shipping list. If numbers do not match, take action to return the answer sheet and the shipping list to ECI immediately with a note of explanation.
2. Note that item numbers on answer sheet are sequential in each column.
3. Use a medium sharp #2 black lead pencil for marking answer sheet.
4. Write the correct answer in the margin at the left of the item. (When you review for the course examination, you can cover your answers with a strip of paper and then check your review answers against your original choices.) After you are sure of your answers, transfer them to the answer sheet. If you have to change an answer on the answer sheet, be sure that the erasure is complete. Use a clean eraser. But try to avoid any erasure on on the answer sheet if at all possible.
5. Take action to return entire answer sheet to ECI.
6. Keep Volume Review Exercise booklet for review and reference.
7. If mandatorily enrolled student, process questions or comments through your unit trainer or OJT supervisor. If voluntarily enrolled student, send questions or comments to ECI on ECI Form 17.

DON'Ts:

1. Don't use answer sheets other than one furnished specifically for each review exercise.
2. Don't mark on the answer sheet except to fill in marking blocks. Double marks or excessive markings which overflow marking blocks will register as errors.
3. Don't fold, spindle, staple, tape, or mutilate the answer sheet.
4. Don't use ink or any marking other than a #2 black lead pencil.

NOTE: NUMBERED LEARNING OBJECTIVE REFERENCES ARE USED ON THE VOLUME REVIEW EXERCISE. In parenthesis after each item number on the VRE is the Learning Objective Number where the answer to that item can be located. When answering the items on the VRE, refer to the Learning Objectives indicated by these Numbers. The VRE results will be sent to you on a postcard which will list the actual VRE items you missed. Go to the VRE booklet and locate the Learning Objective Numbers for the items missed. Go to the text and carefully review the areas covered by these references. Review the entire VRE again before you take the closed-book Course Examination.

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MULTIPLE CHOICE

1. (A01) What pest spins and carries a silken case during its larval stage?

   a. Black carpet beetle.
   b. Furniture carpet beetle.
   c. Casemaking clothes moth.
   d. Webbing clothes moth.

2. (A01) Which is the most destructive carpet pest?

   a. Common carpet beetle.
   b. Black carpet beetle.
   c. Furniture carpet beetle.
   d. Casemaking clothes moth.

3. (A02) The presence of fabric pests is usually discovered

   a. during routine spraying operations.
   b. after they have damaged clothing and furnishings.
   c. while the pests are in the larval stage.
   d. before damage to clothing and furniture occurs.

4. (A03) The best preventive control measure for fabric pests is

   a. dry cleaning or laundering fabrics.
   b. treating fabrics with residual insecticides.
   c. placing clothing in a cold storage facility.
   d. placing clothing and paradichlorobenzene chrystals in a plastic bag and then sealing.

5. (A03) The best corrective chemical control measure for fabric pests is

   a. fumigating the fabrics.
   b. treating fabrics with residual insecticides.
   c. treating baseboards, floor, closet shelves, and walls of areas where fabrics are stored.
   d. placing paradichorobenzene crystals in areas where fabrics are stored.

6. (A04) What pest is considered the most important whole grain pest?

   a. Cadelle.
   b. Rice weevil.
   c. Granary weevil.
   d. Drugstore beetle.

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7. (A04) What larva burrows into the woodwork of grain bins?

a. Granary weevil.
b. Lesser grain borer.
c. Rice weevil.
d. Cadelle.

8. (A05) Which of the following insects is the worst pest of prepared cereals?

a. Red flour beetle.
b. Cadelle.
c. Confused flour beetle.
d. Indian meal moth.

9. (A05) What moth is easily recognised by pale gray forewings with transverse, wavy black markings?

a. Indian meal moth.
b. Angoumois grain moth.
c. Webbing clothes moth.
d. Mediterranean flour moth.

10. (A06) "A pest with reddish legs and a light olive-brown color, mottled with darker brown and gray," identifies the

a. bean weevil.
b. pea weevil.
c. cadelle.
d. red flour beetle.

11. (A06) Which pest lays its eggs only in the field?

a. Bean weevil.
b. Pea weevil.
c. Confused flour beetle.
d. Granary weevil.

12. (A07) What insect is referred to as a cheese skipper?

a. Larder beetle.
b. Red-legged ham beetle.
c. Cheese maggots.
d. Cheesemite.

13. (A07) Which of the meat and cheese pests also infests dog biscuits museum specimens, and dried tobacco?

a. Larder beetle.
b. Cheese maggot.
c. Red-legged ham beetle.
d. Cadelle beetle.

14. (A08) Which beetle dines on such delicacies as strychnine, belladonna, mummies, and lead?

a. Khapra.
b. Cadelle.
c. Cigarette.
d. Drug store.

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15. (A09) When a product is found to contain larvae of a species belonging to the genus Trogoderma, what is the minimum number of insects per pound to justify for condemnation of a commodity?

a. 1.　　c. 6.
b. 3.　　d. 10.

16. (A09) When is the best time to inspect commodities that are brought on base for sale?

a. After prolonged storage.
b. Soon after storage.
c. Immediately upon arrival.
d. After a complaint has been received.

17. (A10) Which of the following may be prevented when cereal products and other foods are stacked against warehouse walls or ceilings?

a. Fire hazard.　　c. Damaged packaging.
b. Rodent harborage.　　d. Adequate inspection.

18. (A10) All of the following are forms of preventive control for stored product pests except

a. palletizing.　　c. fumigation.
b. isolation.　　d. rotation.

19. (A11) Which type of corrective control of stored product pests is restricted to use on walls and floors?

a. Residual spraying.　　c. Space spraying.
b. Radiation.　　d. Reclamation.

20. (A11) Vacuum chambers are recommended for what type of corrective control of stored product pests?

a. Space spraying.
b. Fumigation.
c. High frequency electric fields.
d. Residual spraying.

21. (A12) Which wood material is not utilized by mold fungi?

a. Starches.　　c. Gums.
b. Sugar.　　d. Lignin.

22. (A12) Poria incrassaba is an example of which type fungi?

a. White rot.　　c. Stain fungi.
b. Water conducting.　　d. Mold fungi.

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23. (A13) The maximum permissible moisture content for safe storage of lumber before it is dip-treated is

a.	10 percent.	c.	30 percent.
b.	20 percent.	d.	40 percent.

24. (A13) What percentage of pentachlorophenol is recommended to make wood almost completely impervious to water?

a.	1 percent.	c.	5 percent.
b.	3 percent.	d.	10 percent.

25. (A14) The insect pests most destructive to structures at military activities are

a.	fungi.	c.	carpenter ants.
b.	termites.	d.	carpenter bees.

26. (A15) To what genus do nonsubterranean termites belong?

a.	Reticulitermes.	c.	Xylocopa.
b.	Kalotermes.	d.	Cimex.

27. (A16) What characteristic best distinguishes sexually mature reproductive termites from sexually mature reproductive ants?

a. Termites have two pairs of wings that are of equal length.
b. Ants have two pairs of wings that are of equal length.
c. The first pair of wings are longer than the second pair of wings of a termite.
d. The first pair of wings are shorter than the second pair of wings on an ant.

28. (A16) The body of a termite is described as being

a.	wasp-waisted.	c.	elliptical.
b.	slab-sided.	d.	tubular.

29. (A17) Why is the worker caste of the subterranean termite so important to the colony as a whole?

a. They protect the colony from invaders.
b. They produce eggs to sustain the colony.
c. They produce the food for the members of the colony.
d. They feed, care for, and maintain all of the other members of the colony.

30. (A17) Vicious natural predators of termites are

a.	ant eaters.	c.	man.
b.	monkeys.	d.	ants.

31. (A18) What form is used to record both termite inspections and treatment?

a. AF Form 290.
b. AF Form 2467.
c. DD Form 1532.
d. DD Form 1070.

32. (A18) What is the primary advantage of using termite shields in building construction?

a. They keep termites from penetrating expansion joint fillers.
b. They keep termites from entering cracks in bricks and building blocks.
c. They facilitate detection by forcing extension of termite tubes.
d. They prevent above ground penetration.

33. (A19) When is the best time to provide protection against termites?

a. Immediately after construction is completed..
b. During the final construction.
c. During planning and construction.
d. One year after construction is completed.

34. (A19) The rodding method is a procedure used for

a. preventive termite control.
b. corrective termite control.
c. site sanitation.
d. structural fumigation.

35. (A20) Which one of the powder post beetles is identified by larval tunnels tightly packed with frass and running parallel with the wood grain?

a. Lyctidae.
b. Anobiidae.
c. Bostrychidae.
d. Cerambycidae.

36. (A20) The larvae of which powder post beetles attack the sapwood of pine, oak, beech, alder, and willow?

a. Anobiidae.
b. Lyctidae.
c. Bostrychidae.
d. Cerambycides.

37. (A21) Which adult powder post borers can usually be recognized by their bright metallic colors?

a. Lyctidae.
b. Buprestidae.
c. Bostrychidae.
d. Cerambycidae.

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38. (A22) For use on stored wood subject to dampness, an excellent wood preservative without insecticide is

a. chlorinated hydrocarbon. c. pentachlorophenol.
b. trichlorobenzene. d. trisodium phosphate.

39. (A22) What corrective control for powder post beetles is used to treat laid flooring in buildings?

a. Brushing with an oil solution.
b. Spraying with an oil solution.
c. Spraying with pentachlorophenol.
d. Brushing with pentachlorophenol.

40. (A23) In structures, the most effective preventive treatment against carpenter bees is to

a. spray the surface with pentachlorophenol.
b. spray the surface with trichloromethane.
c. spray the surface with chlorinated hydrocarbons.
d. apply a heavy protective coating of paint.

41. (A23) Carpenter ants and bees use wooden structures to

a. provide nesting sites.
b. provide food for the larvae.
c. escape from their predators.
d. obtain food for themselves.

42. (A24) Which of the common lepidoptera defoliators deposits its eggs on twigs in late fall?

a. White-marked tussock moth.
b. Fall cankerworm.
c. Gypsy moth.
d. Fall webworms.

43. (A24) The common lepidoptera defoliators that feed mainly on trees such as apple, alder, birch, oak, and willow are the

a. white-marked tussock moths.
b. fall cankerworms.
c. gypsy moths.
d. fall webworms.

44. (A25) Which of the webbing lepidoptera defoliators spends the winter as pupa in a thin cocoon on the ground?

a. Fall cankerworm. c. Eastern tent caterpillar.
b. Fall webworm. d. Spruce bud worm.

45. (A25) Which very destuctive webbing lepidoptera defoliator spends its larval stage in protected coverings under bark scales?

a. Fall cankerworms.
b. Fall webworms.
c. Eastern tent caterpillars.
d. Spruce bud worms.

46. (A26) The lepidoptera defoliator that, as a caterpillar, lives in a silken cocoon-like bag to which is attached bits of leaves and stems from the host plant is the

a. bagworm.
b. cutworms.
c. fall webworms.
d. eastern tent caterpillars.

47. (A26) The lepidoptera defoliators that are seldom seen because they usually remain hidden under clods of earth or in the topsoil during the day are

a. bagworms.
b. cutworms.
c. fall webworms.
d. eastern tent caterpillars.

48. (A27) The larvae of which skeletonizing defoliators hatch in the ground and feed on decaying vegetation and plant roots?

a. Japaneses beetles.
b. Fall cankerworms.
c. Elm leave beetles.
d. Cutworms.

49. (A28) The holly leaf miner is the larval stage of a

a. small dark or yellowish fly.
b. small gray moth.
c. wedge-shaped beetle.
d. white with blackspot fly.

50. (A28) The larvae of which type of leaf miner eats kidney-shaped blotches on leaves?

a. Holly.
b. Basswood.
c. Arborvitae.
d. Birch.

51. (A28) The larvae that eat out the inside of terminal leaves are

a. holly leaf miners.
b. basswood leaf miners.
c. arborvitae leaf miners.
d. birch leaf miners.

52. (A29) Chemical control of bagworms is effective only in the

a. late summer.
b. fall.
c. winter.
d. spring and early summer.

53. (A30) Bark beetles and engravers can be recogonized by the characteristic pattern of

    a. straight galleries.
    b. winding galleries.
    c. stripping of bark.
    d. color change in the leaves.

54. (A30) A method used to lessen the attack of bark beetles is to

    a. spray the tree with a protective paint.
    b. spray the surrounding foilage with herbicide.
    c. cut and destroy the infested tree.
    d. score around the base of the tree.

55. (A31) To kill borers within wood or bark you can use

    a. carbon disulfide.
    b. pentachlorophenol.
    c. calcium carbonate.
    d. fertilizer and water.

56. (A31) Newly transplanted trees can be somewhat protected from borers by

    a. wrapping the trunk with paper or burlap.
    b. spraying the roots with insecticide before backfilling.
    c. spraying the new foliage with insecticide.
    d. filling all existing holes.

57. (A32) What minute reddish or yellowish arthropod infests ornamental plants and shade trees?

    a. Aphid.
    b. mealy bug.
    c. Spider mite.
    d. Leaf hopper.

58. (A32) A bug that sucks large quantites of sap from plants and causes numerous small pinholes in the phloem and bark tissue is the

    a. spider mite.
    b. aphid.
    c. mealy bug.
    d. spittle bug.

59. (A32) An insect that is the sole source of some brilliant dyes is the

    a. scale insect.
    b. aphid.
    c. mealy bug.
    d. spider mite.

60. (A33) Insect galls can be differentiated from other types of galls because they

    a. are not as large as other galls.
    b. contain one or more chambers or depressions.
    c. are honeycombed on the plant.
    d. are larger than other galls and are white in color.

61. (A34) Summer oils should not be sprayed if the temperature is above

a. 52° F.
b. 64° F.
c. 78° F.
d. 86° F.

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62. (A34) When it is necessary to spray in areas where cars are parked, what action should be taken?

a. Spray away from the cars.
b. Cover the cars with plastic.
c. Display warning signs one day in advance.
d. No precautions are necessary.

63. (A35) Grubs normally lie in a curled position. The exception to this rule is the

a. June beetle.
b. Japanese beetle.
c. wireworms.
d. billbugs.

64. (A35) Wireworms are most prevalent in

a. dry sandy soils.
b. gardens and orchards.
c. pastures and hay fields.
d. high rainfall areas.

65. (A35) Normally, pavement ants are found in lawns in

a. the Atlantic Coast states.
b. Texas and Louisiana.
c. the West Coast states.
d. the New England states.

66. (A36) The fiery skipper moth is a lawn pest normally found in

a. Texas and Louisiana.
b. the New England states.
c. the Atlantic Coast states.
d. California.

67. (A36) The best way to distinguish between the armyworm and the fall armyworm is that the

a. fall armyworm is more brilliantly colored.
b. armyworm has a white dot on each forewing.
c. armyworm feeds only during the day.
d. fall armyworm remains in the soil at night.

68. (A37) One of the most destructive of the turf attacking insects is the

a. leaf bug.
b. leaf hopper.
c. chinch bug.
d. scale insect.

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69. (A37) Which of the following turf attacking insects are common in the southern states?

a.	Leaf bugs.	c.	Leaf hoppers.
b.	Chinch bugs.	d.	Scale insects.

70. (A38) Sifting broken-up sod through hand sifters is the recommended method for detecting the presence of

a.	grubs.	c.	cutworms.
b.	chinch bugs.	d.	wireworms.

71. (A38) Which of the following turf and lawn damaging insects can be detected by pushing a tin cylinder into the ground and filling the cylinder with water?

a.	Grubs.	c.	Chinch bugs.
b.	Cutworms.	d.	Wireworms.

72. (A39) Nematodes are classified as

a.	free-living.	c.	animal parasites.
b.	plant parasites.	d.	all of the above.

73. (A39) Nematodes are also known as

a.	cutworms.	c.	roundworms.
b.	wireworms.	d.	armyworms.

74. (A40) In which type of root attacking nematodes does the female become fixed in one position where she feeds until death?

a.	Sedentary parasites.	c.	Semiendoparastic.
b.	Endoparasitic.	d.	Ectoparasitic.

75. (A40) Which root type nematode attacks fruit trees?

a.	Root-knot.	c.	Lance.
b.	Meadow.	d.	Stubby root.

76. (A41) What has been the most successful method of controlling nematodes?

a.	Quarantines.	c.	Herbicides.
b.	Soil fumigation.	d.	Water-dispersal nematocides.

77. (A42) How many species of terrestrial snails are found in the continental United States?

a.	725.	c.	800.
b.	750.	d.	825.

78. (A42) The Mediterranean snail that is considered to be the most distructive is the

a. *Theba pisana*.
b. *Achatina*.
c. *Otala lactea*.
d. *Helix asperta*.

79. (A43) How many families of snails are found in the United States?

a. 5.
b. 7.
c. 9.
d. 11.

80. (A43) The aestivation of snails refers to the

a. ability to reproduce asexually.
b. preparation of a nest for eggs.
c. infestation of vegetation by snails.
d. period of dormancy during the summer.

81. (A44) To facilitate inspection what can be used to attract and draw out snails and slugs?

a. Fresh fruits.
b. Dried apples.
c. Sodium chloride.
d. Sugar water.

82. (A44) When inspecting wheeled and tracked equipment for snails, what is recommended in lieu of or in addition to examination?

a. Submersion in chemically treated water.
b. Spraying with diesel oil.
c. Steam or water-jet cleaning.
d. Treatment by infrared lighting.

83. (A45) The best method of cultivating soil in order to destroy snails and snail eggs is

a. discing.
b. cultipacking
c. turning.
d. harrowing.

84. (A45) What predators may be used to control snails and slugs?

a. Hogs.
b. Chickens.
c. Snakes.
d. Lizards.

85. (A46) What is the common size of plant fungi?

a. Size of a dime.
b. Size of a lemon.
c. Microscopic.
d. Macroscopic.

86. (A47) What type of disease, commonly found on rose leaves, appears in the form of raised blisters?

a. Root rot.
b. Dutch elm disease.
c. Damping-off.
d. Powdery mildew.

87. (A48) What is the most effective and sometimes the only method available for controlling most of the fungus diseases of plants?

    a. Application of chemical sprays not chemical dusts on the plants or into the soil.
    b. Application of a chemical spray and dust combination into the soil, never on the plants.
    c. Use of a chemical type seed planted just beneath the existing plant root.
    d. Application of chemical sprays or dusts on the plants, their seeds, or into the soil where the plants are to grow.

88. (A48) What important points should be considered in attempting to control plant disease caused by fungus?

    a. Life style characteristics of each fungus with no particular attention to its habitat preferences.
    b. Life style characteristics of each fungus, its habitat preferences, and its performance under certain environments.
    c. Characteristics of fungi under various climatic conditions with special attention to its rate of growth and appearance.
    d. Special attention to its rate of growth under certain temperatures, with additional attention in its habitat preferences.

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CDC 56650

ENTOMOLOGY SPECIALIST

(AFSC 56650)

Volume 7

Collection, Identification, and Control of Important Vertebrate and Vegetative Pests

Extension Course Institute
Air University

Preface

THIS VOLUME of CDC 56650, *Entomology Specialist*, provides you with knowledge concerning the more important vertebrate and vegetative pets which includes domestic and field rodents, bats, birds, aquatic plants, woody plants, grasses, and herbacious broadleaf plants. In order for you to become a certified pest controller, you must be very knowledgeable in these subjects as well as those previously discussed.

Please note that in this volume, we are using the singular pronouns *he, his*, and *him* in the generic sense, not the masculine sense. The word to which these pronouns refer is person.

Appendixes A and B have been bound as a separate inclosure. This supplement is for use with Volumes 4, 5, 6, and 7.

If you have questions on the accuracy or currency of the subject matter of this text, or recommendations for its improvement, send them to Tech Tng Cen/TTGOX, Sheppard AFB TX 76311. NOTE: Do not use the suggestion program to submit corrections for typographical or other errors.

If you have questions on course enrollment or administration, or any of ECI's instructional aids (Your Key to Career Development, Behavioral Objective Exercises, Volume Review Exercise, and Course Examination), consult your education officer, training officer, or NCO, as appropriate. If he can't answer your questions, send them to ECI, Gunter AFS AL 36118, preferably on ECI Form 17, Student Request for Assistance.

This volume is valued at 36 hours (12 points).

Material in this volume is technically accurate, adequate, and current as of September 1977.

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NOTE: In this volume, the subject matter is developed by a series of Learning Objectives. Each of these carries a 3-digit number and is in boldface type. Each sets a learning goal for you. The text that follows the objectives gives you the information you need to reach that goal. The exercises following the information give you a check on your achievement. When you complete them, see if your answers match those in the back of this volume. If your response to an exercise is incorrect, review the objective and its text.

Vertebrate Pests

THE DOMESTIC RODENT is a major problem on military installations. One of your primary duties is to control these pests. Not only must you contend with the domestic rodent, but you must control several field rodents.

Other field vertebrates that you need to be able to recognize and manage include rabbits, hares, moles, shrews, and predatory animals. This chapter covers these pests as well as bats, birds, and domestic animals.

1-1. Domestic Rodents (Order *Rodentia*, Family *Muridae*)

Three species of murine rodents live in close association with humans: the Norway rat (*Rattus* norvegicus), the black or roof rat *(Rattus rattus)*, and the house mouse *(Mus musculus)*. These three imported murine rodents are far more important to humans and their property than are the rodents that are native to the United States. One or more of these three are found almost everywhere that man dwells. Because these rodents live near humans, they are also known as the domestic rodents.

This section deals with the importance, identification, life cycle, habits, habitats, and control of the murine rodents.

C01. Complete given statements concerning the importance of murine rodents.

Murine rodents inhabit the buildings and destroy the food and property of humans. They also endanger human well-being by being the reservoir or vector for such diseases as plague, murine typhus, salmonellosis, leptospirois, and rickettsialpox. They also serve as the host for ectoparasites that are the actual vectors of some of these diseases. We will divide this discussion of the importance of murine rodents into two parts: economic and medical.

Economic Importance. The murine rodents, especially the roof and Norway rats, cause tremendous financial losses each year by destroying and contaminating food, dilling poultry and other domestic animals, and destroying property.

Destruction of food. Rats eat millions of bushels of grain each year. They eat it in the fields, grain elevators, processing mills, trucks and trains, stores, and homes. Because rats are omnivorous, grain is not the only food product they attack. The eating cycle given above can apply to many other products.

Contamination of food. Rats and mice commonly excrete wastes, both feces and urine, while feeding and, thus, contaminate and make unfit for human consumption about three times as much food as they eat. To give you an idea of the amount of damage that is possible, rats drop from 25 to 100 pellets a day and excrete 10 to 20 cc of urine each day. Another way in which rodents contaminate food is through the shedding of body hairs.

Destruction of poultry and other domestic animals. Rats may destroy hundreds of baby chicks in one night and have seriously injured young pigs, lambs, and calves. This type damage may become a major problem because rats kill not only for food but also for the sake of killing.

Destruction of property. Rats destroy by gnawing. They will gnaw through such items as concrete, brick, wood, and even metal. Such gnawing could cause a fire should a rodent gnaw through the insulation on electrical wiring. Fire could also occur through spontaneous combustion from flammable materials gathered for use as nesting materials. Burrowing rodents can also cause severe damage to structures or runways as they undermine and weaken these facilities. Rodents on aircraft are very dangerous because their consistent gnawing habit could cause damage to electrical lines, pneumatic lines, or control cables.

Medical Importance. Although there are many diseases transmitted by the rat, only the ones of importance to man will be discussed here.

Murine typhus fever. This disease is transmitted from rats (the reservoir) to humans by the rat flea. It is similar to epidemic typhus, which is transmitted by human lice. The rickettsial organisms cause the disease to enter the bloodstream when feces of infected fleas are rubbed or scratched into a fleabite wound or broken skin tissue.

Plague. A plague reservoir exists in wild rodents of the western states and is transmitted from rodent to rodent and from rodent to humans by the bite of rodent fleas. There is always a danger that domestic

Leptospirosis (Weils disease). Human infections result from direct or indirect contact with the infected urine of rodents. The spirochetes which are found in water or on food may enter through mucous membranes, minute cuts or abrasions of the skin. Therefore, Weil's disease is more often found in sailors, miners, sewer workers, fish or poultry dealers, and abattoir (slaughterhouse) workers.

Ratbite fever. The bacteria that cause this disease are found on the teeth and gums of many rats and are transmitted from a rat to a person by a ratbite. The most frequently occurring ratbite fever in the United States is called Haverhill fever.

Salmonellosis. Salmonellosis is a food poisoning disease that causes diarrhea and dysentery. It is spread in several ways. One way is by contamination of edible materials with rat feces containing infective bacteria. Salmonellosis is a common disease found worldwide.

Rickettsialpox. The disease is transmitted from the house mouse to humans by the bite of a mite that the mouse harbors. Rickettsialpox is a mild, nonfatal disease which resembles chickenpox. Although these diseases may not be major problems in the United States at the present time, there is always the possibility of a major outbreak as long as rodents are living near humans. Also, as a member of the military, you may be sent to areas where epidemics of these diseases are frequent; therefore, you should be familiar with the vectors, hosts, and reservoirs of each of the diseases.

Exercises (C01):

1. Murine rodents inhabit the ________ and destroy the ________ and ________ of humans.
2. Some of the places where rats eat millions of bushels of grain a year are in ________, ________ ________, ________ ________, ________ and ________, in stores, and in ________.
3. Rats and mice commonly excrete wastes, both ________ and ____ ____, while ________ and thus, contaminate and make unfit for ________ ________ about three times as much ________ as they eat.
4. Rats often kill for the sake of ______.
5. Rats destroy by gnawing and will gnaw through such items as ________, ________, ________, and even ______________.
6. Fire could occur through ________ ________ from flammable materials gathered for use as ________ materials.
7. Murine typhus fever is transmitted from rats to man by the ________ ________.
8. The bacteria that causes ratbite fever is found on the ________ and ________ of many rats and is transmitted from rats to humans by the ________ of the ________.
9. Rickettsialpox is transmitted from the ________ ________ to humans by the ________ of the mites that the ________ harbors.
10. Salmonellosis is a common disease found ________.

rodents will become infected and carry the infection to man. This disease is usually fatal to rats, fleas, and humans.

C02. Distinguish among the features of the roof rat, Norway rat, and house mouse, and identify the droppings of these murine rodents.

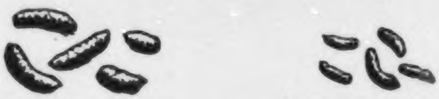
Field Identification of Murine Rodents. Rodent control measures cannot be effective unless you know with which rodent you must deal. Thus, you must know how to identify the three most important species of murine rodents. Table 1-1 describes the physical characteristics that you can use to make your identification. Identifying factors other than physical characteristics, such as droppings, gnawings, or trails, sometimes will be your only clues to a correct identification. See figure 1-1 for examples of the different types of rodent droppings. The following text will give you more information for identification.

Norway rat. The Norway rat *(Rattus norvegicus),* predominantly a burrowing rodent, is the most common and largest of the domestic rats. Numbers of this pest are generally distributed throughout the United States and the temperate regions of the world. The recognition characteristics and biology of the Norway rat not given in table 1-1 are as follows:

Fur: coarse, reddish brown
Droppings: large (up to three-fourths inch long), capsule-shaped.
Sexual maturity: attained in 3 to 5 months.
Gestation period: average 22 days.
Young: average 8 to 12 per litter.
Number of litters: average 4 to 7 per year.
Length of life: average about 1 year.
Harborage: ground level, burrows in ground and under foundations of buildings, and in rubbish dumps.
Range: frequently 100 to 150 feet.
Food and water: omnivorous, garbage, meat, fish, and cereal; daily requirement 3/4 to 1 ounce dry food, 1/2 to 1 ounce of water.

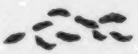
Roof rat. The roof rat *(Rattus rattus),* an agile climber, is a middle-sized rodent with a range confined largely to the South and to the Pacific coast in the United States. It is found most abundantly in the tropical or temperate regions and is rare or absent in the colder portions of the world.

The recognition characteristics and biology not given in table 1-1 of the roof rat are as follows:



NORWAY RAT (BLUNT)
AVERAGE LENGTH ¾"

ROOF RAT (POINTED)
AVERAGE LENGTH ½"



HOUSE MOUSE (POINTED)
AVERAGE LENGTH ¼"

Figure 1-1. Comparison of murine rodent droppings.

TABLE 1-1

CHARACTERISTICS AND MEASUREMENTS OF ADULT MURINE RODENTS

Species	Norway Rat (Rattus norvegicus)	Roof Rat (Rattus rattus)	House Mouse (Mus musculus)
Weight	10 - 17 oz (280 - 480 gm)	4 - 12 oz (110 - 340 gm)	1/2 - 3/4 oz (14 - 21 gm)
Total length (Nose to tip of tail)	12 3/4 - 18 in (325 - 460 mm)	13 3/4 - 17 3/4 in (350 - 450 mm)	6 - 7 1/2 in (150 - 190 mm)
Head and Body	Blunt muzzle; heavy thick body 7 - 10 in (180 - 255 mm)	Pointed muzzle; slender body 6 1/2 - 8 in (165 - 205 mm)	Small 2 1/2 - 3 1/2 in (65 - 90 mm)
Tail	Shorter than head plus body, carried with much less movement, comparatively, than roof rat. Lighter-colored on under side at all ages. 6 - 8 1/2 in (150 - 215 mm)	Longer than head plus body generally moving whip-like, uniform coloring top and bottom at all ages and for all subspecies. 7 1/2 - 10 in (190 - 255 mm)	Equal to or a little longer than body plus head. 3 - 4 in (75 - 10 mm)
Ears	Small, close set, appear half buried in fur. Rarely over 3/4 in (20 mm)	Large, prominent, stand well out from fur. Generally over 3/4 in (20 mm)	Prominent, large for size of animal, 1/2 in (15 mm) or less
Hind Foot	Usually over 1 1/2 in (40 mm) from heel to tip of longest toe.	Generally less than 1 1/2 in (40 mm) from heel to tip of longest toe.	Feet are shorter, darker, and broader than most wild mice. Generally less than 3/4 in (20 mm) from heel to tip of longest toe.

Fur: three color phases in the United States: the black rat (Rattus rattus), black to slate-gray; Alexandrine rat (Rattus rattus alexandrinus), tawny above and grayish-white below; and the fruit rat (Rattus rattus frugivorus), also tawny above with a white to lemon-colored belly.
Droppings: medium-sized (up to 1/2 inch long), spindle-shaped.
Sexual maturity: attained in 3 to 5 months.
Gestation period: average 22 days.
Young: average 6 to 8 per litter.
Number of litters: average 4 to 6 per year.
Number weaned: average about 20 per year per female.
Length of life: average about 1 year.
Harborage: above ground level, indoors in attics, and between walls; outdoors in trees and dense vine growth.
Range: frequently 100 to 150 feet.
Food and water: Omnivorous; vegetables, fruits, and cereal grains; daily requirement 1/2 to 1 ounce dry food and up to 1 ounce water.

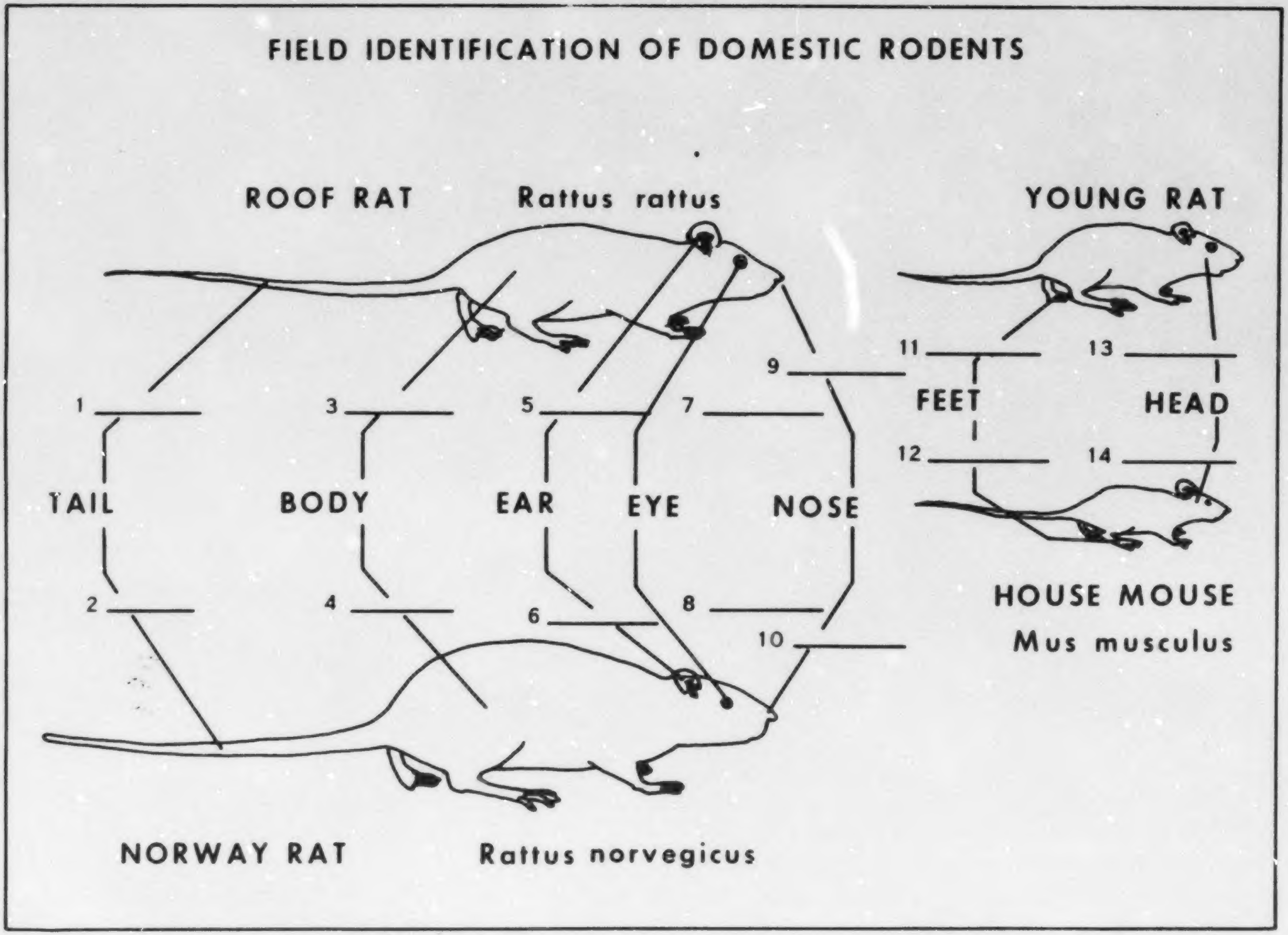
House mouse. The house mouse *(Mus musculus)*, the smallest of the domestic rodents, is widespread and abundant throughout the United States. It is found from the Tropics to the Arctic regions throughout the world.

The recognition characteristics and biology of the house mouse not given in table 1-1 are as follows:

Adult weight: 1/2 ounce.
Fur: dusky gray.
Droppings: small (1/8 inch long), rod-shaped.
Sexual maturity: attained in 1½ months.
Gestation period: average 19 days.
Young: average 5 to 6 per litter.
Number of litters: as many as 8 per year.
Number weaned: average 30 to 35 per year per female.

Exercises (C02):

1. Using figure 1-2 and table 1-1, place in the numbered spaces (except 11 and 13) descriptive statements which distinguish these murine rodents from one another.



FIELD IDENTIFICATION OF DOMESTIC RODENTS
ROOF RAT
Rattus rattus
YOUNG RAT
1
2
3
4
5
6
7
8
9
10
11
12
13
14
TAIL
BODY
EAR
EYE
NOSE
FEET
HEAD
HOUSE MOUSE
Mus musculus
NORWAY RAT
Rattus norvegicus

Figure 1-2. Comparison of physical characteristics (objective C02, exercise 1).

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7. Droppings of these murine rodents are
    a. Small (1/8 inch long), rod-shaped. The rodent is the ____________ .
    b. Large (up to 3/4 inches long) capsule-shaped. The rodent is the ________ .
    c. Medium size (up to 1/2 inch long), spindle-shaped. The rodent is the _______ .

C03. Complete given statements pertaining to the life cycles of murine rodents.

Life Cycles of Murine Rodents. The life of the average rat or mouse is fairly short, and the young mature rapidly. As you recall, the gestation period is only about 3 weeks. In addition, it is possible for females to be producing young almost continuously. Fortunately for control efforts, several things can slow this reproduction. Mating is not always successful, or is not even attempted immediately after young are born. Then, too, if a female is nursing young and is also pregnant, birth of the new litter may be delayed as much as a week. The length of this delay depends on the number of nursing young and the size of the unborn litter.

Young rats and mice enter this world none too gently. Large litters are the rule, and in the confusion at birth some of the newborn may be killed and eaten. Birth is usually preceded by a flurry of nest building. Although the female remains quiet during the birth, she is very nervous and may be disturbed by intrusions. Often when a rat or mouse nest containing young is disturbed, the mother will move the young to another place. Many litters thus moved probably do not survive. In any event, although large numbers of young rats and mice may be born, many of them die or are killed before they are weaned.

Those young rats and mice which survive the accidents at birth grow very rapidly although they are virtually helpless. They have almost no control over their own body heat or temperature and may become very cold when left untended for a period of time in cold weather. Infant Norway rats can survive a body temperature as low as 34° F. (1.12° C.). An adult rat is killed under most circumstances when body temperature reaches 59° F. (15.12° C.). The growing infant rat slowly acquires the ability to control its own body temperature. At about 73 days of age it can maintain a high temperature even under cold conditions.

Newborn rats and mice are helpless in many ways: their eyes and ears are not open: they are hairless; and their legs are small and poorly developed. They move about by a combination of wriggling and paddling. In the Norway rat the ears open in about 3 days, but no signs of hearing can be detected until the rat is 12 days old. During this early period mice and rats respond largely to heat and touch, although they probably have some ability to smell. In all three species fine hair appears on the body in about a week. They open their eyes at about 12 to 14 days of age. At this time the already active youngsters enter a period of intense investigative behavior. They begin to take excursions out of the nest, often as a result of following the mother when she leaves. For about 3 weeks the young depend on the mother for food. They begin to take solid food in the middle of the third week. At the end of this period they can live away from the mother if forced to.

Mice can actually survive on solid food as soon as the eyes are open although they normally do not begin to take such food until a few days later. In the wild, the mother rat or mouse may feed her litters until they are 4 to 5 weeks old. By this time their activity is essentially adult except for sexual behavior and fighting. These latter activities appear later and at the same time, in rats at 2 to 3 months of age, and in mice when they are about 2 months old.

Exercises (C03):

1. The life of the average rat or mouse is fairly ______ and the young mature ______ .
2. Although large numbers of young rats and mice may be born, many of them ______ or are ______ before they are weaned.
3. Young mice and rats have almost no control over their own ______ heat or temperature and may become very cold when left ______ for a period of time in cold weather.
4. Newborn rats and mice are helpless in many ways: their ______ and ______ are not open; they are ______ ; and their ______ are small and poorly developed.
5. In all three species fine hair appears on the body in about ______ .
6. They open their eyes at about ______ to ______ days of age.
7. For about ______ weeks the young depend on the mother for food.
8. Mice can actually survive on solid food as soon as the ______ ______ although they normally do not begin to take on food until a few days later.

C04. Discriminate between true and false statements pertaining to the habits of murine rodents, and correct those that are false.

Habits of Murine Rodents. To control murine rodents effectively, you know about their habits. This objective covers the general activity, reaction to strange objects, climbing, jumping, swimming, nesting, burrowing, and gnawing habits of murine rodents.

General activity. Young rats and mice gradually become familiar with their surroundings while undergoing a "training" period with their mother. Their first trips away from the nest are often by accident. Nursing young, clinging to their mother's nipples, are sometimes dragged from the nest as she leaves. Later they may follow her for a short distance when she leaves the nest. This habit of following increases until finally they regularly accompany her as she goes about her normal activities. During this period they learn their home area by associating with and imitating their mother. However, there is no evidence that she consciously tries to teach them. They learn by imitation and experience, part of the latter being gained when they accompany each other on forays. By the time the youngsters are 3 months old, they are very active and are completely independent. This level of activity remains high until they are about nine months old, when old age overtakes them and they slow down.

When food is abundant, the rat shows the greatest activity during the first half of the night. The rat becomes most active at or shortly after dusk. This activity continues until about the middle of the night. The house mouse shows a similar pattern of nocturnal activity, and, in addition, shows a second lesser activity peak starting well after midnight and lasting until dawn. Superimposed on this nocturnal activity are short periods of restlessness and activity ocurring every few hours throughout the day and night, these shorter activity periods are related to periodic stomach contractions in the rat. The major pattern of nocturnal activity breaks down, however, when the rat is hungry.

Knowing where the rats and mice are likely to go is important in such control procedures as rat-proofing. They like to use regular paths or runways, especially along walls or objects that present a vertical plane. When a rat or mouse wants a piece of food, it will run under and behind things until it gets as close to the food as it can. Then, if the food is in the open, a short dash is the only exposure to danger. The farther away from runways that traps or baits are placed, the smaller the chance that they will be visited.

Reaction to strange objects. Rats and mice very often carefully avoid strange objects, even strange food. This habit contributes greatly to their ability to survive even in the most dangerous environments. Strange objects may be dangerous or even deadly. It is to the rodent's advantage to investigate them very cautiously. Interestingly, this "strange-object" reaction has led to many stories about the "wily" and "highly intelligent" rat. The answer to a great number of these stories is that the rat recognized the trap only as a strange object to be avoided, not specifically as a trap. Probably one of the reasons that the last few rats or mice in a builidng are so difficult to kill is that these survivors have the strongest reaction to strange objects. Hence, they avoid all new attempts to kill them. Rats may avoid new food for several days. This is an important fact in poisoning operations. When the rat or mouse first begins to take a new food, it may only take "token" amounts. If these amounts contain a sublethal dose of poison, they may make the animal sick and thus strengthen the avoidance reaction. This is the biologic basis for the use of unpoisoned bait, or prebaiting, before the poison is added. The feeding studies also indicate that hunger causes the avoidance of strange objects to break down more quickly.

In environments where "strange objects" appear regularly, however, rats and mice may show little or no evidence of the avoidance reaction. This is particularly true in such places as warehouses where a constant turnover in harborage and food is occurring. Rats feeding on garbage are accustomed to new foods and may accept anything edible.

Climbing ability. Roof rats and house mice are notoriously good climbers, and even the Norway rat can climb well if it has to. There are records of Norway rats having crossed wide city streets by walking telephone wires. This use of wires is common among roof rats and house mice.

Rats and mice can climb the vertical walls of most brick buildings. This is understandable for the smaller house mouse, but even the larger rats climb well. They can climb any vertical surface where they can get a toenail hold. By means of a fingernail test of the surface of the average brick building, you can see how easily a rodent could hang on. Even stucco is often rough enough to permit ready climbing. Vine-covered walls are perfect runways, and since the vines afford concealment they can be used by day or night. Smooth surfaces can be climbed if there is a pipe, a corner, or something else against which the rat or mouse can brace its back. Rats have been found using both the outside and inside of rusty 3-inch pipes placed against walls. Nailheads or screwheads placed too close together can serve as steps for rodents to climb. Rats have crossed sheet metal flashing by catching the top edge with the claws of their forefeet and swinging across overhand. When improperly installed, sheet metal guards have failed to stop rats. Even the rat guards used on ship mooring lines are seldom installed properly and, therefore, do not prevent crossings.

In rodent control work, however, it is necessary to draw a line between the possible and the probable in rodent climbing. For example, it is possible for rats to climb most types of vertical walls, but the chance of rats climbing these walls without supporting wires or pipes is quite remote. Remember that rats and mice do not climb at every opportunity. They work only as hard as is necessary, and only when they are driven by hunger or lack of shelter will they try the feats mentioned above. This practice greatly simplifies the necessary precautions against rat entry and reduces ratproofing costs.

Jumping ability. Because rats can reach as much as 13 inches along smooth vertical walls, a safety factor must be added to rat guards to make certain that the rodents do not pass. The distance that should be completely clear of possible holding points is 18 inches. Rats can be expected to make a standing high jump of nearly 2 feet. With a running start and a bounce against the vertical surface two-thirds of the way up to give them a boost, rats can jump a little more than 3 feet. Under these conditions even the much smaller house mouse can jump more than 3 feet high. Jumping out and down from a height of 15 feet, a rat can cover a horizontal distance of 8 feet. It can do even better with a running start.

Swimming ability. All three of the introduced murine rodents are good swimmers. This is especially true of rats; they have been known to swim as much as 1/2 mile in open water. There are reports that rats swim up through floor drains without hesitation. They probably come from a manhole or other break in the sewer lines, although rats may live in the sewer itself.

In many large cities, rats use the older sewer systems as regular highways. If you are responsible for ratproofing inspection, you should be familiar with the layout of the major sewer lines in your area. Information is especially important on small lines which were abandoned but not removed when larger mains were laid. This is very important in cities where the first sewers were made of wood.

Nesting. Rats and mice will nest wherever they can find safety close to food and water. They can use holes or burrows in the ground to hide and nest outdoors. In buildings, rats and mice use double walls, the space between walls and ceilings, closed-in spaces around counters, or any place hidden from view that enemies cannot reach. The more rubbish that is piled around, the more objects that are stacked in corners or closets, the greater the number of hiding and nesting places.

Generally, rats and mice build their nests in hiding places that are relatively quiet. They gather whatever soft material is nearby, or tear up paper and cloth to line the nest.

Rat nests generally are bowl-shaped and about 8 inches in diameter. Occasionally, they are completely roofed over. In addition to cloth and paper, such materials as grasses, excelsior, small twigs, and other soft materials may be used.

Mouse nests are similar to rat nests but are smaller, about 5 inches in diameter. Normally, they are completely covered, and entrance is through a small hole in one side. Nest-building activity is greatest just before young are born and at the start of cold weather.

In addition to disclosing nesting sites, a careful search may reveal hidden resting and feeding stations. These are places safe from enemies where rats and mice can eat or rest undisturbed. These stations are usually found somewhere between the food supply and the nest or burrow entrance. To these spots the mice and rats carry or drag food, and they leave behind feces, food wrappings, and scraps. The ideal condition, of course, is where harborage is such that runways, too, can be concealed. Too often this condition is found around homes and business places.

Burrowing. The three murine rodents differ considerably in their tendency to burrow. This habit is most highly developed in the Norway rat. As an adaptation to burrowing, the ears of this species are small, and the hairs in the ear openings keep dirt out.

The roof rat is more adapted to a life of climbing. It burrows only in areas where Norway rats are absent. Its burrow system is seldom extensive.

House mice burrow where other harborage is not available. In and around buildings mice seldom have trouble finding cover, but in open fields they burrow well and extensively.

Because of a peculiarity in rat-burrowing habits, rodent control workers have developed the L-shaped curtain wall to protect buildings from rat entry under the foundation walls. When rats and mice attempt to burrow under a wall, they often begin a short distance away and burrow at an angle toward the wall. Usually they reach it before they are 18 inches deep, and upon reaching it they may follow it downward. Most important, once they reach the wall they will not dig away from it to go around an obstruction.

Gnawing. Nature seldom has provided an animal with a more effective cutting tool than the rodent's front or incisor teeth (fig. 1-3). Young rats and mice begin to gnaw as early as the second week of life. Throughout their lives the teeth keep growing rapidly. In adult laboratory rats, the average growth for upper incisors is 4½ inches a year, and the lower incisors grow 5½ inches. The growth rate in wild rats probably is similar. This fast growth allows continuous gnawing without wearing out the cutting edge of the teeth. It may, however, cause trouble. Sometimes rodents are found with a front tooth broken and the one in the opposing jaw very long. This bears out the idea that the grinding action of the opposing teeth helps keep the teeth short. It is believed that the hard enamel on the front of the rodent's incisors wears away the softer dentine on the back of the opposing tooth and thus helps keep the tooth sharp. It is difficult to see how gnawing, as such, could keep the teeth sharp, although this idea still persists. It would be like a chisel that grew sharper the more it was used.

Rats and mice will gnaw almost anything. Some of this gnawing may be only to keep the teeth short, for some of it seems to serve no other purpose. This would explain why many holes are gnawed much larger than necessary. It also explains random cutting of furniture legs and counter posts.

To get to food, rats and mice gnaw any material with a gnawing edge that is softer than the enamel of their teeth. This material includes such things as wood, paper board, cloth sacks, lead pipes, cinder block, asbestos, and aluminum. They have pierced concrete

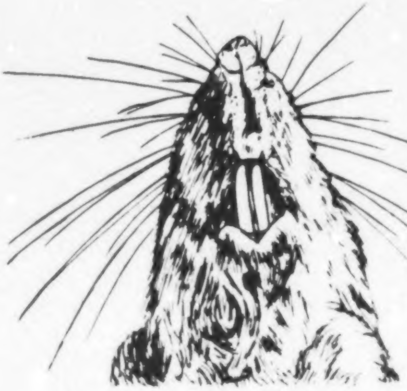

Figure 1-3. Incisor teeth.

used for ratproofing before it had time to harden and have even gnawed through sun-dried adobe brick. Roof rats are even better at gnawing than are Norway rats.

Exercise (C04):

Identify the following statements as correct or incorrect. Amend those that are incorrect.

____ 1. You must know the habits of rodents to control them effectively.

____ 2. Young rats and mice are trained by their father.

____ 3. Rats become more active at dawn.

____ 4. Rats and mice avoid strange food.

____ 5. Rats and mice can climb vertical walls of brick buildings.

____ 6. Rats can make a standing high jump of 4 feet.

____ 7. Rats are good swimmers. They can even swim up through floor drains.

____ 8. Rats and mice generally build their nests in noisy places.

____ 9. The burrowing habit is most highly developed in the Norway rat.

____ 10. The teeth of rats and mice keep growing throughout their lives.

C05. Complete given statements concerning the feeding habits of murine rodents.

Feeding Habits of Murine Rodents. The feeding habits of rats and mice are sufficiently different to require different controls. All three species have regular eating habits, determined by differences in the species, in the amount and kind of food, and in the dangers involved in securing it.

Rats usually begin searching for food a little after sunset each day. However, mice are small and hard to see, and come out during the day whenever possible. They all treat food much the same way, once they find it. Usually, they carry or drag it to a hiding place before eating it. Occasionally they eat the food on the spot if it is in small enough pieces. Usually, however, rats and mice will eat in the open only if they are starved, if no enemies are around, or if the pieces are too big to move to cover.

Rats are fairly steady eaters. Mice are nibblers, taking a bit here and a bit there. Hence, in efforts to poison mice a great many baits should be put out quite close together to make sure that the mice nibble enough to kill them.

Norway rats feeding on mixed garbage perfer such foods as meats, grain, grain products (such as oatmeal), cooked eggs, and potatoes. On the other hand, they show very little desire for such foods as raw beets, peaches, onions, celery, cauliflower, and green peppers. There appears to be an aversion to highly spiced foods.

The choice of food is determined largely by the environment of the rat or mouse. For example, citrus fruits are not preferred by rats and mice, but in Florida, the roof rat is considered a serious pest in citrus groves.

Exercises (C05):

1. The feeding habits of murine rodents are determined by differences in the ________, in the ________ and kind of ________, and in the ________ involved in securing it.
2. Rats usually begin searching for food a little after ________ day.
3. Rats are fairly ________ eaters, where mice are ________.
4. Norway rats feeding on mixed garbage preferred such food as ________, ________, ________ ________ and ________.
5. The choice of food is determined largely by the ________ of the rat or mouse.

C06. Identify as true or false given statements pertaining to the signs of the presence of murine rodents, and correct those that are false.

Survey and Inspection for Murine Rodents. Often you must inspect an area to determine the extent of rat or mouse infestation. Often rodents leave characteristic signs of their activities behind them. These signs can often tell you the species present, the degree and location of the infestation, and the habits of the animals. It is always desirable that you observe as many signs as possible before you make a decision as to the presence and degree of any rodent infestation.

Sight. The most positive proof of infestation, of course, is to see a live rat or mouse. However, because these rodents generally are nocturnal and secretive in their habits, live animals seldom are seen. As a rule, it is only in very heavy infestations that rats and mice show themselves when humans are present. They are especially secretive if there is much human activity in the area.

Dead animals may indicate either a current or a past infestation. If the carcass is dried or reduced to a skeleton, it may mean only a former infestation. If many recently dead animals are found, find out whether poisons have been used in the area. If poisons have not been used, there is the possibility that an epidemic disease, such as plague, is present among the rodents. If disease is suspected, do not handle the dead rodents with your bare hands. If possible, place them in cloth or paper bags to prevent the escape of fleas and other ectoparasites. Hold them for examination by specialists to determine the cause of death.

Sound. The various noises made by rats and mice may give clues as to their presence and location. These noises are rarely heard unless the area is otherwise quiet. Upon entering an infested building, stand still to allow the sound of your own entry to subside so that rat and mouse activity may be resumed. You may hear the sounds of running, gnawing, and scratching, especially from double walls and floors. Various squeaks and churring noises are also produced. The squeaking may accompany fighting and may occur intermittently for several minutes. Also, youngsters in the nest make faint squeaking noises.

Droppings. Presence of rat and mouse feces is one of the best indications of an infestation. All three animals commonly produce quantities of droppings. These droppings may be a key to the species present and its relative abundance.

It is important to be able to determine the age of rat and mouse droppings. This information is necessary in deciding whether an area is currently infested. Fresh droppings are soft enough to be pressed out of shape and often have a glistening, moist appearance. The color varies according to the kind of food eaten, but usually it is black or nearly black. Within a few days, depending on climatic conditions, droppings become dry and hard. Later the surface becomes dull, and with great age they assume a grayish dusty appearance and may crumble easily when pressed with a stick. The appearance of the surface alone, however, may be misleading. Droppings may be black and shiny and still be hard and crumbly. Old droppings dampened by rain or other moisture may appear fresh, but when crushed they do not have the putty-like consistency of fresh droppings.

The quantity and sizes of fresh droppings found in an area may give an indication of the number of animals present. Fresh droppings mean that at least one rat or mouse is present. Since only rarely are Norway and roof rats found occupying the same area, presence of several sizes of fresh droppings means that several ages of rats are present and that reproduction probably is occurring. This often is the case in extensive infestations. Droppings are most numerous along runways, near harborage, in secluded corners, and near food supplies. In contrast, the burrows, and nests, especially, are usually very clean and have no droppings. Rats and mice have actually been observed carrying feces from nests and burrows.

The number of rodent droppings found in any area depends not only on the amount of rodent activity but also on how often floors are swept and how rapidly stored goods are moved. The absence of droppings may not always mean that no rodents are present, for droppings are present irregularly in infestation. Sometimes they are abundant, sometimes scarce. On the other hand, and presence of old droppings, even in quantity, does not mean that the area is currently infested.

Runways and rub marks. Since rats and mice generally occupy only a limited area, they may use the same pathway many times. Out of doors or on earthen floors these runways may appear as clean-swept, well-packed earth paths 2 to 3 inches wide. In dusty areas, runways may consist of tracks made in dust by passing rats or mice (fig. 1-4). Occasionally, you may even see the wavy line of a dragged tail. In many areas rats and mice leave dark smears or rub marks when they rub against objects as the result of natural oils and dirt on their bodies.

Outdoors, runways are easily seen in dense vegetation, such as lawn grass, and they may even be conspicuous on bare earth. However, the location of runways usually reflects the rodent's generally secretive habits. Most often, they are found along walls, under boards, behind stored objects and accumulated litter, and in similar places. It is important to search such places carefully.

Rat and mouse runs in or on buildings are often marked by more or less extensive rub marks. You can find these marks around gnawed holes, along pipes and beams, on the edges of stairs, along walls, or anywhere else that the rodent is likely to travel. Swing marks made by rats passing under floor joists along a beam generally indicate the presence of roof rats. Norway rat runs are more often near the floor. House mouse runs, on the other hand, may be anywhere. They are the most difficult to locate because they are small and often very faint. It is especially important to search behind vertical pipes near walls for evidence of rub marks. Small vertical pipes and columns are a favorite means by which rats and mice change floors.

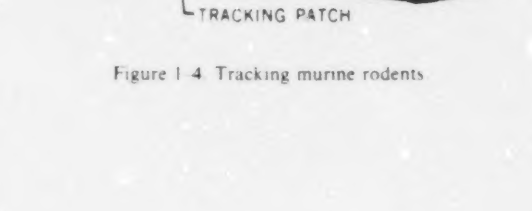

Figure 1-4. Tracking murine rodents

You can often tell how old a rat or mouse run is. A fresh run over earth will generally be hard-packed and free of dirt and litter. Heavy use may even give it a shiny appearance. Dusty cobwebs across a run, of course, mean that it is no longer used. Fresh rub marks and smears are soft when scratched. Old marks are brittle and may flake off.

By tracing rat and mouse runs, you can find the harborage, the food and water supply, and the means of entry into buildings may. This information will help you take the right control measures.

Tracks. You may find tracks anywhere along rat and mouse runs, both outdoors and inside. You can see tracks more clearly with side illumination from a flashlight than with direct light from above (fig. 1-4). Especially good places to find tracks are in dust in little-used rooms and in mud around outdoor puddles. Rat tracks are fairly large. A hind foot of a walking Norway rat may leave a print 1½ inches long. Roof rat prints are about the same size. Mouse footprints are conspicuously smaller, rarely being even 1/2 an inch long, and are much closer together.

Tracks found outdoors generally are fresh because wind and rain would quickly erase them. The age of tracks indoors is more difficult to estimate; they may appear fresh long after having been made. If the dust is thin enough, you can determine their age by pressing a finger lightly into the dust near the track and observing the color. Fresh tracks should show about the same color as the finger mark, while old tracks will be different in color and have less sharply defined edges. Knowing the speed with which dust falls may be helpful. In a dusty flour mill where there is a heavy deposit every day, visible tracks are probably quite fresh. In the still air in the unexcavated area beneath a building, tracks last a long time.

A very helpful procedure is the use of a fine dust for tracking. You can dust any fine powder, such as pyrophyllite or flour, on a susepcted runway and inspect it later for footprints. Spread the powder smoothly to a depth of no more than 1/8 inch.

Gnawing. Recent gnawings through wood can be distinguished by the fresh, light-colored appearance of the gnawed surface and the presence of small, chewed pieces or cuttings in the vicinity. The edges of the gnawed area become darkened in a few days, and small cuttings are soon scattered or swept away. Another way to determine the age of gnawed openings is to notice the sharpness of the bitten edges. A freshly gnawed opening has sharp edges which scratch the animals as they pass through. They will stop and nibble at the offending edge so that as the openings become older, they acquire well-rounded edges. Evidence of recent gnawing is one of the most reliable signs for determining the presence of rats and mice.

The extent of damage to materials may be an indication of the degree of infestation. You must be careful to determine whether the gnawing was done by one or more species. A mixed infestation of rats and mice may be present, and damage done by mice may be ascribed to the rats. When recently delivered materials are damaged, you can assume that the infestation is a current one. In this case, the extent of damage may be a very reliable index to the number of animals present.

Exercises (C06):

In the following list, mark each statement "C" for correct and "I" for incorrect. Amend the incorrect statements.

___ 1. The most positive proof of infestation, of course, is to see a live rat or mouse.

___ 2. If many recently dead animals are found, you should ask about the use of poisons in the area.

___ 3. The various noises made by rats and mice may give clues as to their presence and locations.

___ 4. The droppings are not usually a key to the species present and its relative abundance.

___ 5. The quantity and size of fresh droppings found in an area may give an indication of the number of animals present.

___ 6. Out of doors or on earthen floors these runways may appear as clean-swept, well-packed earth paths two to three inches wide.

___ 7. The hind feet of a walking Norway rat may leave a print 1½ inches long.

___ 8. A way to determine the age of gnawed openings is to check the sharpness of the bitten edges.

C07. Complete given statements pertaining to sanitation control of murine rodents.

Sanitation for the Control of Murine Rodents. The primary factors influencing the degree of infestation are the amounts of food and harborage available. Few rats are found in buildings where food is not handled. The cleanliness of an establishment is a most important factor affecting the number of rats present. When waste food is piled on the floor, in open cans, or in other unprotected sites, little else is needed to support rats. Rat infestations can usually be traced to unsanitary conditions, consisting chiefly of infrequent refuse collection and inadequate disposal practices. General sanitation as a rodent control measure includes primarily a planned and continued program of collection and disposal of debris, rubbish, and garbage, and the proper stacking of food supplies. Such practices reduce available food and harborage for rats.

Sanitation for the control of rats and mice also involves storage of all garbage and rubbish in rodentproof containers and the proper storage of usable materials. You should eliminate structural harborage, such as small, protected inclosures under cabinet shelves and stairs. If you remove harborage and food sources, rat and mouse populations will be permanently reduced.

Make sure refuse storage facilities include enough cans of approved capacity to hold all garbage and rubbish that normally accumulate between collection days.

Proper storage of usable materials reduces available food for rodents. Make sure all foodstuffs are stacked 12 to 18 inches off the floor, as shown in figure 1-5.

Frequent sweeping of floors removes rodent food and permits ready detection of fresh signs. A white band 6 inches wide painted along the floor next to walls in foodhandling locations can help you see droppings, tracks, and other signs that indicate the presence of rodents.

You should perform regularly scheduled inspections to detect any new evidence of rodent infestation. Effective and permanent control of rats and mice can be attained only through a continuous sanitation program.

Exercises (C07):

1. The cleanliness of an establishment is a most important factor affecting the ______ of ________ which may be present.
2. Rat infestations can usually be traced to ________ conditions, consisting chiefly of infrequent ________ collection and inadequate ________ practices.
3. Make sure refuse storage facilities include enough ________ of ________ capacity to hold all ________ and ________ that normally accumulate between collection days.
4. Make sure all foodstuffs are stacked ______ to ______ inches off the floor.
5. You should perform regularly scheduled ______ to detect any new evidence of ________ infestation.

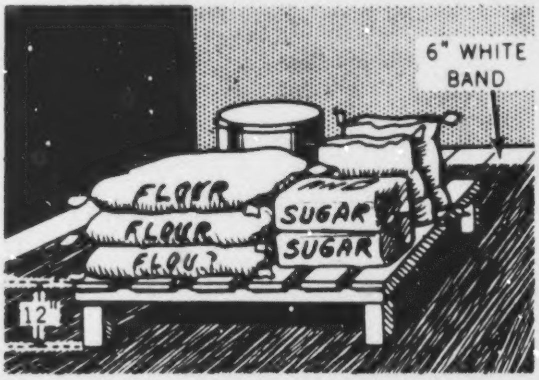

Figure 1-5. Storage of usable materials.

C08. Complete given statements pertaining to controls other than sanitation for murine rodents.

Construction and Maintenance Control. Rodentproofing (fig. 1-6) existing buildings to prevent and control rats is sometimes necessary. Sheet metal of 26-gage or heavier, 1/4-inch mesh hardware cloth, and neat cement are suitable materials for use in ratproofing. Openings more than 1/4-inch wide in the interior of warehouses should be closed. Other openings, such as cracks around doorways, gratings, and windows less than four feet above the ground through which rats may enter directly or by enlarging the opening should be covered with 1/4-inch mesh hardware cloth or other suitable ratproofing material. Openings around boxed-in piping and wire conduits should be closed. Conduits for wiring should be closed and limited, if possible, to sizes that will prevent passage of rats and mice. Fire stops in double walls and floors of wood construction should exclude potential rat runways along beams. Spaces between walls should be blocked. Doors should be self-closing and should fit tightly. Wood sills and doors at ground level may be sheathed in sheet metal to prevent gnawing.

Rats can be kept out of buildings through tunneling by extending a wall downward 24 inches below the ground surface, with a horizontal lip projecting 12 inches out from the base. When the rats hit this block, they almost always stop digging. This curtain wall has a twofold purpose: it precludes the possibility of rat infestations that result in the spread of disease and the loss of foodstuffs; it prevents the burrowing which results in undermining of walls and their possible subsequent collapse.

Mechanical Control. Traps are useful when poisons fail or are too risky. Box-type and cage-type traps catch rodents alive for breeding and for ectoparasite removal in disease studies. The snap trap is one of the most effective methods for killing rats and mice, particularly mice. You must fasten the bait securely to the trigger. For rat control, you can expand the trigger with cardboard or screen wire and use it unbaited.

The number "0" steel trap usually catches rates alive. This trap is preferred when the rat is to be examined for ectoparasites or when blood samples are to be taken. Steel traps are generally used unbaited. The trap should be set with the jaws open across the runway and securely fastened with a chain.

Cage or box traps are usually less convenient and are not as efficient as steel traps, but they catch rodents uninjured. Placing cage traps in dark places or covering them with burlap bags increases catches.

Chemical Controls. Poisoning programs are effectively used before sanitation or cleanup programs are begun, in order to prevent a mass movement and spread of rodents. Rodent killing without good sanitation is ineffective because these rodents rapidly regain the original population level through their high birth and survival-of-young rat.

Baiting. A poisoned bait contains a poisoning agent or rodenticide, a food, and sometimes an emetic. The following bait materials are suggested: fresh meats, bacon, fresh or canned fish, yellow cornmeal, corn, hulled oats, rolled oats, cracked wheat, bread, cake, chicken scratch feed or mash, seeds, apple, banana, peach, pear, pineapple, melon, tomato, sweet or Irish potato, peanut butter, nut meats, prepared dog food, candy, cheese, coconut, and butter.

Norway rats are inclined to favor meat and fish. Roof rats prefer fruits and vegetables. Both readily accept sweets, grains, and nut meats. Mice seem to prefer bacon, sweets, grains or seeds, peanut butter, cheese, apples, or sweet potatoes.

Fresh baits are the most acceptable to rats and mice. Mix only enough bait for immediate needs. A binder of vegetable, mineral, or fish oil is often added to cereal or dry baits to hold poison and dry bait together, to aid in mixing, and to increase the absorption rate of poison into the rat's body (Storer, 1952). Do not use water or milk as a binder as it will cause baits to sour, mold, or spoil quickly. You can use glycerine in place of oil or water as a binder. To keep baits from freezing, add about 25 percent glycerine by weight or volume to protect the baits to about 20° F. You can retard rancidity by adding 0.025 percent Dupont DDPD, an antioxidant now widely used in livestock feed. Oatmeal contains a natural antioxidant. A mold inhibitor such as 0.1 percent of 2, 4, 5-trichlorophenylacetate may prevent mold formations in baits placed in humid locations, but will reduce palatability of bait slightly. Sodium sulfite (1 percent) is a preservative sometimes added to perishable baits. Bacon fat, gravy, syrup, or molasses are used as a combination lure and binder. Cereals or grains may be used with meats or fish to reduce costs. A discoloring agent, such as charcoal, is added as a safety factor.

An emetic, usually tartar emetic (antimony potassium tartrate), is mixed with arsenic trioxide, zince phosphide, thallium sulfate, and ANTU baits to protect other animals even though the acceptability of such baits is thereby reduced. Rats are among the few animals that are unable to vomit.

Baits may be used in solid form as cubes or slices coated with the more toxic poisons like zinc

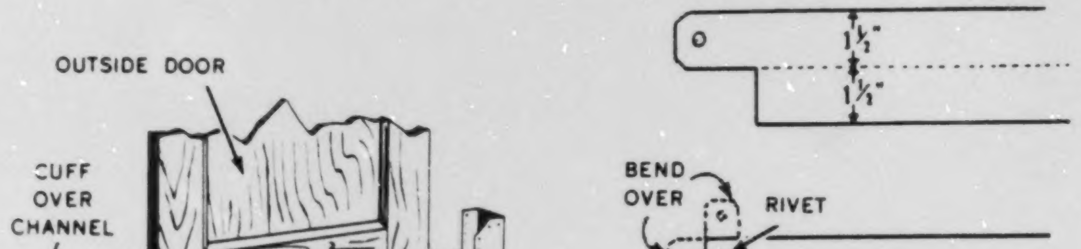

Figure 1-6. Methods of rodentproofing.

phosphide, or ground and thoroughly mixed with the poison. Ground baits may be distributed in about 1/2-inch diameter balls, loose or wrapped in 4-inch squares of waxed paper ("torpedoes").

Baits should be used liberally where you find many recently left signs of rats. A major fault in unsuccessful poisoning programs is the use of too few baits. Good places to set baits are in or near rodent burrows, runs, and harborage. Collect single-dose poison baits that are uneaten after two days. Burn or bury rodent carcasses.

Water requirements of rats and mice can be the basis for successful poisoning of these animals. Poisoned water bait consists of water and a rodenticide. If normal sources of drinking water can be eliminated or reduced, chances for success with this method are enhanced. Even though mice may depend on the water obtained from food as their major source of water, they will usually drink water. If their normal supply of food has a low moisture content, their need for drinking water will be greater.

Anticoagulants require a different method of use than other rodenticides. Bait mixtures are frequently placed in paper pie plates or permanent bait stations, as shown in figure 1-7. The number of pie plates or bait stations vary with the degree of infestation. Small pie plates hold 1/4 to 1/2 pound, whereas permanent bait stations often hold over a pound of bait mixture. Anticoagulant bait mixtures are usually exposed for a minimum of 2 weeks. Repeated doses must be consumed by the rodent for a period of 5 or more consecutive days in order to kill. Therefore, you must protect other animals and shield baits from the weather with bait boxes, boards, pipes, or cans. Note locations of all bait containers so that inspections can be made rapidly and consumed bait replaced. At each inspection smooth the bait so that you can see any new signs of feeding. Replace moldy, wet, caked, or insect-infested baits with fresh ones. If successive inspections show that bait is undisturbed, move it to an area showing fresh rodent signs.

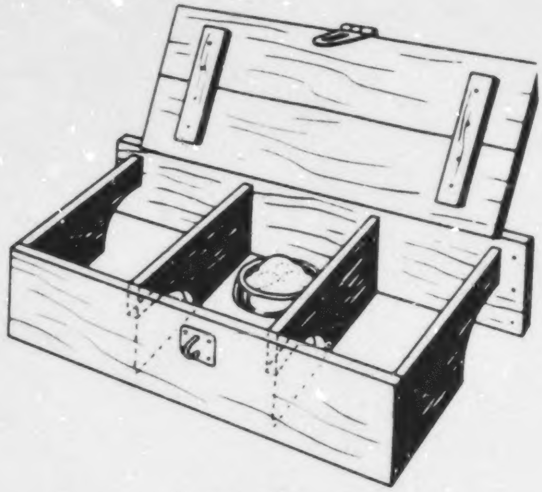

Figure 1-7. Bait stations.

Use shallow bait containers. Fasten them to the floor surfaces or be sure that they are heavy enough to prevent rodents from dragging them to their burrows. A roofing tack driven through containers into the floor reduces spillage and movement.

Be sure to mix baits as directed. Too much poison may give bait a strong taste or odor. Too little will not kill and may result in "bait shyness." Excessive amounts of poison increase the danger to man and domestic animals. Poor mixing results in nonuniform baits, poor kills, and a speedier development of bait shyness. Mechanical bait mixing equipment is necessary where large quantities of bait are mixed on a routine basis.

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CAUTION: You must clearly label poisons and mixing equipment. Do not use mixing equipment for other purposes. Lock up poisons and mixing equipment when not in use. Treat all poisons with respect. Avoid inhaling powders or getting poisons on hands, clothes, or utensils from which they may reach the mouth. Always mix poisons in a well-ventilated place, particularly when you are mixing dry ingredients.

Burrow gassing. Burrow gassing (cyanide dusting) is used as a supplementary measure for killing rodents but should not be attempted by untrained operators. Several materials are available for this purpose, one being calcium cyanide. Cyanide dust is very effective when it can be blown into a burrow system. Calcium cyanide dust is not as effective when the ground is extremely dry; some soil or air moisture is needed to convert dust to gas.

CAUTION: Cyanide fumes are highly toxic and rapidly fatal. You must avoid inhaling dust or fumes. Cyanide gas is lighter than air; therefore, DO NOT gas burrows leading under occupied buildings. Indoor fumigation requires thoroughly trained professionals.

Exercises (C08):

1. Sheet metal of ____________________ -gage or heavier, ________________ mesh hardware cloth, and __________________ cement are suitable materials for use in ratproofing.
2. Rats can be prevented entry to buildings through tunneling by extending a wall ______ inches below the ________ surface.
3. The ______________ trap is one of the most effective methods for killing rats and mice, particularly ____________________.
4. Roof rats prefer ________________ and ______________ as food.
5. __________________ incorporated into bait increase the absorption of poison into the rats body.
6. Water requirements of rats and mice can be the basis for successful ____________ of these animals.
7. Poisoned water bait consists of ____________ and ________________________.
8. Too much poison may give bait a ________________ ____________________ or ____________________________.

9. Excessive amounts of poison increase the danger to ________________ and ________________.
10. Burrow gassing is used as a ____________ measure for killing rodents but should not be attempted by ______________ operators.
11. Because cyanide gas is lighter than air, you must not gas burrows that lead under ________________.

1-2. Field Rodents

While domestic rodents pose a continuing problem in many areas, numerous other rodents also require control. The many types of field rodents (also called feral rodents) are "native" species in the areas where they are found, and they do not follow people from place to place. Though some common names, such as "field mice," are widely used, the species differ from place to place. In addition to rats and mice, you may also have to control several types of feral squirrels.

C09. Identify as true and false given statements pertaining to the importance of native mice and rats.

Importance of Native Mice and Rats. The importance of the various native rats and mice of the family Cricetidae (or Muridae) depends on their species, their numbers, and the type and location of the military installation.

They may all serve as reservoirs of disease. While many members of this family are primarily nocturnal, some are sufficiently active in daylight hours to be attacked by biting flies. A single *Neotoma* live-trapped in Texas was a host for fleas, ticks, and three warble-fly larvae. In addition, this animal had plague. Wood rat nests in the Southwest are often infested with various species of *Triatoma*, which transmit the trypanosome of Chagas' disease.

The overall importance of these rodents at military installations is primarily economic. Native rats and mice can damage communication lines. This is particularly true of field telephone cable which, on the ground, obstructs rodent runways. The rats and mice remove the insulation and often sever the cables. Rodents can find access to parked aircraft within which they destroy control and communication cables. Repellent-treated communication cables are now available.

Rice rats, and to a great extent the cotton rats, damage waterways and impoundments by burrowing. Deer mice, or white-footed mice, are normally destructive only at the larger military installations with many acres of undeveloped lands. When white-footed mice are very numerous, they can become pests: in logged-over forest areas where they destroy the seeds that remain in the ground or that fall from the seed trees left for the purpose of reforestation, in new areas to be seeded to forest trees, in grainfields, particularly those containing shocks of corn and wheat, and in feed and food storage places in farm buildings and houses. They also eat the buds and bark of young trees, but, in this respect, they are not nearly so destructive as meadow mice.

The injuries inflicted by meadow mice and pine mice vary greatly from year to year, depending on the abundance of the rodents, the nature and extent of their food supply, and weather conditions. The fluctuation in the numbers of the mice is continual, irregular, and abrupt, owing to the varying birth rate, disease, availability of food, and the extent to which the rodents are preyed upon by their enemies among wild birds, mammals, and snakes. Thus, the mere presence of these mice is a menace requiring continous close observation.

Even relatively little gnawing may greatly damage trees if it occurs at vital points. As a rule, the greatest injury to trees is inflicted during winter under cover of snow. Damage is usually more severe, therefore, during a hard winter with deep snow than during a mild one. The rule is not invariable, however, as severe injury has been recorded at all seasons and under a great variety of conditions.

The kinds of crops injured by field mice are practically without limit, but orchard trees, nursery stock, small fruits, and shrubbery probably suffer the most damage. Root crops, tubers, and bulbs are very attractive to mice, particularly to pine mice, and losses often approach in severity those caused by injury to fruit trees. Mice are fond of clover and alfalfa also, and the aggregate annual loss from inroads on these crops is considerable. Cereals are damaged most heavily in the shock but are subject to attack at all times. Because of these different habits, the greater part of the injury to trees and other vegetation by the meadow mouse is inflicted above the ground; injury by the pine mouse is inflicted below the surface, where, in the case of crops, it often remains unsuspected until harvest, or, in orchards, until the foliage of the undernourished, girdled trees begins to wilt. Meadow mice occasionally girdle the trunk of a tree below the surface of the ground, but they seldom continue to remove the bark from the roots as pine mice do.

Deep snow and lack of clean cultivation enable meadow mice to work above the ground level without fear of detection. The reason that it is important to distinguish between the two mice is that mechanical protectors and clean cultivation around trees, which are successful aids in controlling damage by meadow mice, have little effect on pine mice which do not rely on surface vegetation for food or protection.

Exercises (C09):

1. Place the letter T before the correct statements.
   ___ a. Considerable damage to communication lines is done by native mice and rats.
   ___ b. Deer mice or white-footed mice damage waterways and impoundments by burrowing.
   ___ c. Rice and cotton rats are normally destructive only on large military

installations with many acres of undeveloped land.

___ d. Meadow mice usually will girdle the trunk of a tree above the ground.

___ e. Root crops, tubers, and bulbs are very attractive to pine mice.

2. List the letter of the false statements and correct them.

C10. Associate the names of native mice and rats with their identifying characteristics.

Recognition Characters and Biology of Native Mice and Rats. Native mice and rats belong to several families. There are many species with diverse food habits. While many are essentially omnivorous, they have, for the most part, adapted to a vegetarian diet. A few are distinctly destructive. Most can, at times, be detrimental to human welfare.

Meadow mice and pine mice. Although these mice are closely related, their habits differ, and, as these habits have a bearing on control practices, it is important to be able to distinguish the groups.

The range of the common meadow mouse and its allies includes almost all of North America southward to Guatemala, as well as the northern two-thirds of the Eurasian Continent. The range of the pine mouse is restricted to the eastern half of the United States, from the Atlantic coast to eastern Kansas and Nebraska, and from the Gulf of Mexico to the Great Lakes.

The two types may be distinguished readily by their appearance, by the nature of their burrows, and by the kind of injury they do. The mice of both of these groups, often called voles, are blocky little animals with relatively coarse fur, usually dark brown in color, and with small, beady, black eyes and almost-concealed ears. The pine mouse is somewhat the smaller of the two. Its reddish-brown fur is less shaggy and more velvety. Its tail is short, being about the same length as the hind foot. The tail of the meadow mouse, on the other hand, usually is nearly twice as long as the hind foot. The average weight of meadow mice is 35 grams (1¼ ounces) and that of pine mice 25 grams (approximately 1 ounce). The females of each species weigh slightly less than the males.

Meadow mice are very prolific and under favorable conditions produce up to 13 litters of young a year. The number of young in a litter varies from 1 to 11, the average being five. The size of the litter fluctuates with the population level of the mice, large litters predominating when mice are becoming abundant. Pine mice are less prolific; although they also may produce several litters a year, these number only one to five young each.

Both meadow mice and pine mice are active throughout the year, although the former are most restricted in movements during the winter, and the latter are probably less in evidence during dry, hot weather. The outstanding difference in the habits of these two mice is that the pine mouse is a burrowing animal, living and feeding very largely underground, whereas the meadow mouse, although constructing shallow tunnels and nesting chambers underground, feeds mostly on the surface. Both of these voles are primarily vegetarian, though pine mice will feed on insects when insects are abundant.

White-footed mice. The white-footed mice, also known as deer mice, are widely distributed throughout North and Central America. They are found from sea level to the vegetation line of the highest peaks and from the heavily timbered areas to the desert.

There are many species and subspecies, but all have the characteristic white underparts and white feet. The color of the sides and upper parts varies from dark gray (nearly black) in forms inhabiting regions of heavy rainfull to light yellowish-brown in those living in desert regions. The species also vary in size, the combined head and body length running from 80 to 170 mm and tail length from 40 to 205 mm. The weight of adults ranges from 15 to 50 grams (1/2 to 2 ounces). All have large ears, prominent eyes, and tails at least one-third the total length of the animal.

White-footed mice are almost completely nocturnal. They do not make runways of their own as the meadow mice do. They use such trails as the runways of meadow mice and the tunnels of moles and pocket gophers.

They are found in practically all types of habitats—in woodlands and swamps, along water-courses, in the wide, open spaces of the upland prairies, about rocks and cliffs, and in deserts. Those inhabiting the prairies, open cultivated areas, and fence rows usually make their nests in short, simple burrows. Those in woodlands live largely on the surface of the ground, building their nests and living quarters among the roots of shrubs and trees, in decayed stumps and hollow trees, and under logs. They may even make use of deserted nesting cavities of birds or abandoned birds' nests in bushes. A few live and travel about in trees. They may also establish temporary quarters in cultivated fields and make permanent homes in barns and houses where the house mouse is not abundant.

These mice do not hibernate. Their little tracks may be seen in the snow the day following the coldest night, showing that they had been out seeking food.

White-footed mice are very prolific. They breed throughout the year in the temperate regions and produce one to nine young at a litter. Although they occur throughout the United States in great numbers, they concentrate in excessive abundance only in certain areas where they become of economic importance. They are extremely numerous in the Western States.

As might be expected from their wide distribution, white-footed mice consume a great variety of foods, but they apparently prefer seeds, nuts, and grains. The seeds include those of grasses, weeds, shrubs, and trees. They often store them in burrows and in the cavities of old stumps. They will devour the bodies of mice that have been caught in traps and will kill and eat pocket mice. They also eat insects, their eggs, and their larvae.

Wood rats. Various species of these large rats are widely distributed throughout North and Central America. They have long, hairy tails, which are bushy in some species. The ears are large and membranous. The skull is long, angular, and heavy. These rats are chiefly vegetarians. They eat flowers, fruit, seeds, stems, and bark. They often carry their food to their dens where the discarded portions of plant material may be added to the mounds of sticks and twigs. Cactus and other fleshy plants serve as moisture sources in arid areas where water is not available.

Rice rats and cotton rats. These rats are distributed widely in North, Central, and South America. The rice rat eats a variety of seeds, sedges, fruit, and berries. It takes the large seeds of grama grass, wild rye, and marsh grass and is sometimes a pest in rice-fields. When these foods are in short supply, the rice rat goes to the shore where it feeds on small crustacea and mollusks exposed at low tide. It also feeds on insects. The larger cotton rat has similar food habits and is a pest of sugar cane and sweet potatoes. In addition, it has proved a menace to ground-nesting birds as it will eat both eggs and young.

Exercises (C10):

1. Match column A with column B.

Column A	*Column B*
___ 1. Long, hairy tails which are bushy in some species. Ears are large and membranous.	a. Meadow mice.
___ 2. Pests of sugar cane and sweet potatoes.	b. Pine mice.
___ 3. Have short tails, approximately the same length as the hind foot.	c. White-footed mice.
___ 4. Have tails approximately twice the length of the hind foot.	d. Wood rats.
___ 5. Takes large seeds of grama grass, wild rye, and marsh grass, and is sometimes a pest in rice fields.	e. Rice rats.
___ 6. These do not hibernate.	f. Cotton rats.

C11. Complete given statements concerning the inspection and control of feral rodents.

Inspection and Control of Feral Rodents. Inspection for the native mice and rats involves a determination of the cause of damage and a search for runways and tracks. Native mice and rats can be controlled at military installations by trapping or poisoning.

Trapping. This is the best way to determine species and numbers. Meadow and pine mice are easily trapped in small wooden-based snap traps. Set these traps in the runways and at right angles to them so that a mouse following its usual route will pass directly over the trigger. Near the entrances to burrows is a good location for traps. For best results, the trap should be baited with oatmeal, apples, or vegetables, but mice can be caught in an unbaited trap if it is set properly in a runway. For convenience in finding a trap, mark the site with a bit of cotton twisted on a nearby weed or twig or on a stick stuck into the ground. Examine the traps and reset them twice daily. For trapping white-footed mice about buildings, the small wooden-based snap trap is very satisfactory. Bait the traps with breakfast rolled oats or nutmeats. Mice can be controlled around seedbeds in forestry nurseries by trapping if enough traps are used to cover the area well. Set larger traps for the wood rats and cotton rats.

Baiting. The most effective and least expensive way to control meadow and pine mice is to use poisoned baits. For large-scale operations, you can also use poisoned baits to reduce the numbers of white-footed mice. Although the effectiveness of baits varies in different localities, even under some unfavorable local conditions, the proper application of well-prepared poisoned baits will destroy a sufficient number of the mice to protect trees and crops.

In many cases, nearly all the meadow mice and pine mice may be killed by baits poisoned with zinc phosphide and strychnine. For control of deer mice, strychnine alkaloid proves only fairly efficient under most conditions. In those localities in which the acceptance of strychnine-poisoned bait is very low, you can use zinc phosphide baits as a followup. Zinc phosphide is highly toxic to mice, and is taken readily.

Most phosphide compunds deteriorate rapidly on exposure to the air, but zinc phosphide retains its toxicity for three weeks or more after exposure on dry bait material. On moist bait, it loses its toxicity more rapidly, but, even so, its toxic period is sufficiently long to make the bait effective. Zinc phosphide is insoluble in water but slightly soluble in fats and oils. Hence, oils may be used in the formulas.

To reduce the concentration of zinc phosphide and increase the volume of the toxic material (rodenticide) so as to obtain a more uniform distribution of the poison on bait materials, blend one part by weight of finely powdered magnesium carbonate thoroughly with two parts of zinc phosphide. One-half ounce (15 grams) of the blended material, hereafter referred to as zinc phosphide rodenticide, as sufficient for ten quarts of apple cubes or three quarts of steamed rolled oats. When finely pulverized (micro-sized) arsenic trioxide is available, you can use it in the same manner as zinc phosphide. It does not deteriorate as does the zinc phosphide, nor does it give as effective results, but it may be used as a substitute.

Strychnine alkaloid is an effective poison, but its bitterness and its initial physiological action in cramping the muscles may cause the mice to fail to eat enough at one time to be fatal. In western states where the mice are accustomed to feeding on grains, strychnine placed on oat baits often produces satisfactory results.

There are four good bait materials for meadow and pine mice: fruits, vegetables, grains, and seeds. Of the fruits, the apple is best; of the vegetables, sweet potato or carrot; and, of the grains and seeds, oats.

Deer mice prefer steamed rolled oats or wheat. However, breakfast rolled oats and corn meal are accepted fairly well and may be employed in a limited way. Such special baits as steamed rolled-oat groats and hulled sunflower seeds are well-accepted by these mice. You can use them extensively if the materials are available at a reasonable cost. Bait formulas and preparation instructions are given in Appendix A of the supplement to Volumes 4, 5, 6, and 7.

Meadow mice are trail makers, and deer mice often follow these trails. You can find the trails in orchards in tall grass, under mulch, in ruts, and along furrows. You can usually tell whether a runway is in use by its appearance and by the presence of freshly cut, short pieces of grass stems or of fresh droppings on the trail floor.

Place poisoned baits directly on the floor of used trails and cover them with a handful of grass or other litter. Baits not placed in trails are usually wasted. In areas in which only pine mice or pine mice and moles but no meadow mice occur, there may be few or no trails on the surface of the ground. This is often the case in sandy loam soil. The presence of mice is indicated by small, open holes about 1 inch in diameter. You can drop poisoned baits into these holes. Bait the area thoroughly, taking care to see that both the surface trails and the deeper pine mouse burrows are treated. Control depends as much on complete coverage of all mouse-infested sites within the area as on the effectiveness of the poisoned bait. Place baits at all rock outcrops, along stone walls and drainage ditch banks, as well as at the base of each tree where you find mouse trails or holes. You can protect communication cables from rats and mice by treating them with repellent compounds. The degree of protection depends on the compound used, on its application, on the species of rodents in the area, and on the length of exposure.

Exercises (C11):

1. Inspection for the native mice and rats involves a determination of the cause of ______ and a search for ______ and ______ .
2. The best way to determine species and numbers is by ______ .
3. Native mice and rats can be controlled at military installation by ______ or ______ .
4. The bait used to trap white-footed mice about buildings is breakfast ______ or nutmeats.
5. In many cases, nearly all the meadow mice and pine mice may be killed by baits poisoned with ______ phosphide and ______
6. There are four bait materials that are acceptable to meadow and pine mice: ______ , ______ , ______ , and ______ .
7. Poisoned baits should be placed directly on the floor of used trails and covered with a handful of ______ or other ______ .
8. Baits should be placed at all rock outcrops, along stone ______ and drainage ditch ______ as well as at the base of each ______ where mouse trails or holes are found.

C12. Identify three members of the squirrel family.

Feral Rodents in the Squirrel Family. Of the many species in the squirrel family (Sciuridae), the most troublesome at military installations are the ground squirrels *(Citellus)*, the prairie dogs *(Cynomys)*, and the woodchuck, groundhog, or marmot *(Marmota)*. The burrowing members of the squirrel family can cause serious economic damage (including erosion) by their extensive digging. But the greatest importance of these rodents is that they serve as reservoirs of disease, primarily plague and tularemia. They also are hosts of the ticks that carry Rocky Mountain Spotted Fever.

Ground squirrels (Citellus). These rodents (fig. 1-8), erroneously called gophers, are found in western North America from Alaska to Mexico. They are also found in eastern Europe and Asia south to Turkestan and western Mongolia.

Those of western North America range in length from 23 to 48 cm from the tip of the nose to the end of the tail. They are gray to reddish brown. Most species have large ears, a rather long and narrow skull, well-developed cheek pouches, and long, fully haired tails.

These feral rodents burrow extensively when numerous. Temporary burrows are sometimes made to extend the area of foraging. They feed chiefly upon green vegetation early in the spring. Later they will feed on grass stems, fruit, berries, and many species of insects. They store seeds. In areas with cold winters, ground squirrels will hibernate.

Prairie dogs (Cynomys). These rodents are also found in the western United States and northern Mexico. They are havier bodied than are ground squirrels and have shorter hair which lies close to the body. The head and back are tan or light brown. While the ground squirrels tend to be somewhat gregarious, the prairie dogs are truly colonial and live in "towns." Like the ground squirrel, the prairie dog feeds primarily on vegetation, but it will eat insects readily.

Woodchucks, groundhogs, or marmots (Marmota). These feral rodents are found from the eastern United

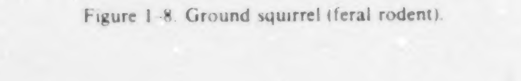

Figure 1-8. Ground squirrel (feral rodent).

States to the mountain ranges of California. They are also found in Western Europe and most of Asia. They are heavy, robust, well-furred animals. The crown of the head is darker than the body. Where terrain permits, burrows are constructed on hillsides or low, sloping banks. While they will occasionally eat grasshoppers, snails, and small birds, they are more herbivorous than are ground squirrels or prairie dogs. They enjoy clover, alfalfa, flower heads, and other herbaceous plants. In some mountainous areas of western United States, they are nearly as gregarious as ground squirrels. In the eastern United States, their burrows usually are more isolated. Hibernation usually lasts through late winter.

Exercises (C12):

1. Name the feral rodents to which the following descriptions apply. Give the species as well as the common names.
    a. This rodent is living in northern California. It is gray to reddish brown. In the winters, it will hibernate.

    b. This rodent is living in Georgia. It is heavy and well-furred. The crown of its head is darker than its body. It is mostly herbivorous, but it may eat small birds.

    c. This rodent is living in a colony in northern Mexico. It is heavy-bodied with a tan head and back.

C13. Identify as correct or incorrect given statements pertaining to the control of members of the squirrel family.

Control of the Squirrel Family. There are no special inspection techniques for burrowing members of the squirrel family. You can control them by baiting, gassing, trapping, or shooting them. Your choice depends primarily on the size of the job.

Shooting. This can be the easiest and cheapest control for an occasional ground squirrel or woodchuck. However, land use may dictate against this form of control. Shooting is not an economical method for control in large areas of infestation.

Trapping. Like shooting, trapping can be a cheap and effective control technique where you have a limited infestation. Steel traps baited with bacon or with peanut butter will readily take ground squirrels. Be sure to attach the traps to sturdy objects to keep them from being dragged deep into burrows.

Gassing. Various fumigants are effective for the control of ground squirrels, prairie dogs, and woodchucks. To use carbon monoxide, park a jeep, truck, or tractor near the burrow, and use a hose to direct the exhaust to the burrow. Pack soil around the hose. This procedure can be effective, but it is time consuming.

Calcium cyanide dust and carbon disulfide are useful in control over small areas or as cleanup applications to eliminate scattered rodents not killed by poison when an area is baited. They are also useful at times when the animals will not accept poisoned baits. You can pump either of these materials into the burrows with appropriate equipment. You can also put carbon disulfide into the burrows on cotton waste balls soaked in the liquid fumigant. There is some fire hazard connected with the use of this material because the liquid burns readily, and the vapor is highly explosive. You can apply calcium cyanide to burrows with a tablespoon attached to the end of a 20-inch wood handle. Place a tablespoonful (1½ to 2 ounces) of the toxicant on the burrow floor as far in as you can reach. Cover the mouth of the burrow with sod. Place the sod upside down so that less soil will fall in to cover up the cyanide dust. Calcium cyanide dust is most effective when the soil is damp. Fumigants also have the advantage of killing fleas and other insects in the burrows. This action is important in plague control. Carbon disulfide is less effective in this respect than in calcium cyanide.

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Poisoning. The use of poisoned baits is usually the most economical technique for control of burrowing members of the squirrel family. You can find bait formulas and preparation instructions in Appendix A of the supplement to Volumes 4, 5, 6, and 7.

Although there are no materials registered for this purpose, strychnine bait has proved most effective for squirrels when they are "pouching" (gathering seeds or grain in their cheek pouches to store or to carry away to some favored place for eating). The strychnine is absorbed through the pouch lining. When squirrels are feeding, they remove the hull of the grain and are not likely to be poisoned by the strychnine coated on the hull. During periods of maximum feeding (early spring), use the zinc phosphide bait formula should be used. Prebaiting part of a squirrel-infested area with unpoisoned grain is a recommended test to determine whether the squirrels will eat the bait or "pouch" it. NOTE: You must get approval from the command intomologist before you use poison baits.

If approval has been granted, scatter poisoned grain bait thinly with a spoon. Place it on hard, bare ground and along or near open spaces on runways, thereby making it easy to find. The recommended dosage is about 1 tablespoonful of grain scattered over 1 to 2 square feet. One quart of a strychnine-coated grain provides 30 to 35 tablespoonfuls. When domestic animals might be endangered, the poisoned grain should be placed only in the burrows or scattered very thinly. Find out about local conditions affecting control operations from local, county, or state agencies having an interest in this problem.

Exercises (C13):

1. Place the letter "T" before the correct statements.

_ a. The choice of methods of controlling burrowing members of the squirrel family depends primarily on the size of the job.

___ b. The easiest and cheapest control for an occasional squirrel or wood chuck is usually shooting.

___ c. Steel traps baited with bacon or peanut butter may readily take ground squirrels.

___ d. Calcium cyanide dust used to gas ground squirrels and prairie dogs is most effective when the soil is dry.

___ e. Carbon disulfide is more effective than calcium cyanide in killing fleas and other insects in burrows.

___ f. The use of poisoned baits is usually the most economical technique for control of burrowing members of the squirrel family.

___ g. During periods of maximum feeding, the zinc phosphide bait formula should be used.

___ h. Prior approval must be obtained from the command entomologist before using poison baits.

2. Correct all incorrect statements.

C14. Complete given statements pertaining to the importance, recognition characters, biology, inspection, and control of pocket gophers.

Importance, Recognition Characters, Biology, Inspection, and Control of Pocket Gophers. Pocket gophers are rodents in the family Geomyidae. Members of this family are found from Saskatchewan south to Panama, but are most abundant in the western United States and Mexico. These animals occasionally require control at military installations.

Importance. The mounds made by gophers, besides being unsightly, are a mowing obstacle in lawns and other turf areas. They also create a safety hazard in airfields and training areas. Gopher burrows frequently cause leaks in dikes and embankments holding impounded water and thus contribute to serious soil erosion. These animals also serve as reservoirs of plague.

Recognition characters and biology. Pocket gophers are well-suited for a life underground and are seldom seen outside their burrows. The forelimbs have greatly enlarged digging claws. The naked tail has a tactile tip. The large, heavy incisors protrude beyond the lips. On the sides of the mouth are the openings for the fur-lined, external cheek pouches. The ears are minute, and the eyes are small. Pocket gophers feed on roots, tubers, bulbs, and other vegetables. They burrow extensively, pushing earth up to form aboveground mounds. Main tunnels and laterals are common. In the continual search for food, a single pocket gopher may extend tunnels to cover an area of an acre or more.

Inspection. There are no special inspection techniques for pocket gophers. You can tell their burrowing from that of the burrowing members of the squirrel family because squirrels burrow for dwelling purposes rather than in a continual search for food. You can distinguish pocket gopher burrowing from the burrowing of the moles because moles work nearer the surface and push the sod up in a nearly continuous ridge.

Control. You can control pocket gophers by baiting, trapping, or gassing. Before you select a control methods, inspect the areas adjacent to the damaged area for tunneling to determine the true extent of the control operations required. You may want to use one of the following methods:

a. Gassing. The fumigants and use techniques discussed for the control of ground squirrels apply to control of pocket gophers, with two additional requirements. (1) Because a single pocket gopher will tunnel extensively, more gas and more effort is required per animal killed. (2) Make every effort to seal off the burrows to prevent excess escape of the gas.

b. Trapping. Trapping is effective for control of gophers if it is conducted by trained personnel. The Macabee gopher trap can produce good results. Select freshly constructed mounds for placing traps. Each gopher mound is more or less fan shaped, with the plug of the lateral burrow at the base of the fan. You can locate the main runway with a probe or by digging out the lateral to its junction with the main tunnel. Set two traps, one facing each way, in the main runway because the gopher may approach from either direction. In some instances, traps are effective when set in a lateral that is long enough that the trap does not extend into the main runway. Cleanout the plugged opening of the burrow with a garden trowel or long-handled spoon. Enlarge the opening sufficiently to admit the trap. Place the traps in gopher runways 12 to 18 inches inside the burrow, which is left open or only partially closed. Air and light will bring the gophers out to repair the tunnel. Baiting gopher traps is not recommended. Fasten the traps to suitable stakes with a small wire or cord. When traps are not fastened, captured gophers often escape with them.

c. Poison baits. The most effective and economical method of gopher control in large areas is the use of poison baits. Locate the main runway should with a probe, and place the bait in the runway. Summer and fall are the best seasons for poisoning gophers. Bait formulas and preparation instructions are given in Appendix A of Supplement to Volumes 4, 5, 6, and 7.

Exercises (C14):

1. Pocket gophers also serve as reservoirs of __________.

2. Pocket gophers create a safety hazard in ________ and ________ areas.

3. The forelimbs of the pocket gophers have greatly enlarged ________ __________.

4. The pocket gophers feed on ________ , ________ , ________ , and other vegetables.
5. The burrowing members of the squirrel family burrow for shelter purposes rather than a continual search for ________ .
6. Pocket gophers can be controlled by ________ ________ or ________ .
7. When you are gassing for control of pocket gophers, make every effort to ________ off the burrows to prevent excess ________ of the gas.
8. Baiting gopher traps is ______ recommended.
9. ________ and ______ are the best seasons for poisoning gophers.

1-3. Other Field Pests

Although rodents are the primary vertebrate pests, you sometimes must control several other field animals. Some of these other vertebrates are: rabbits, hares, and pikas; moles and shrews; and predatory animals.

C15. Identify given statements concerning rabbits, hares, and pikas as being true or false.

Rabbits, Hares, and Pikas. These animals belong to the order Lagomorpha. They differ from rodents in that they have four upper incisor teeth rather than two. The second pair of incisors is smaller than and behind the first pair.

The pikas, or conies, belong to the family Ochotonidae. They have short, rounded ears, a vestigial tail, and hindlimbs that are not elongated as are those of hares. Pikas are limited to the Rocky Mountain slopes of western North America. They are of little significance at military installations. Hares and rabbits belong to the family Leporidae.

Importance. Hares and rabbits serve as the primary reservoir of tularemia. They are also reservoirs of spotted fever and, to a lesser extent, of plague. The rabbit tick, *Haemaphysalis leporis palustris,* plays an important role in transmitting spotted fever and tularemia from rabbit to rabbit and thus in maintaining natural reservoirs. Rabbits and hares are of economic importance at military installations because they damage trees and erosion control plantings. Damage is most prevalent at installations in the western United States where large populations of jack rabbits frequently develop. Although epizootics drastically reduce their numbers at intervals of about 7 years, other control measures are often needed.

Recognition characters and biology. Hares and rabbits are heavily furred animals with long ears and elongated hindlegs. They inhabit most of the major landmasses and some islands.

The true rabbits, of the genus *Sylvilagus,* include: (1) the cottontails, which range from southern Canada south to Argentina and Paraguay; (2) the smaller brush rabbit of the United States Pacific coast; and (3) the marsh rabbits or swamp rabbits of the southern and southeastern United States. The young of this genus are born naked, blind, and helpless.

The hares, of the genus *Lepus,* are represented by the jack rabbit and by the varying hare, or snowshoe rabbit. The young hares are born in an advanced state with the eyes open and the body well-furred. They can move about soon after birth.

Control. Techniques employed for the control of hares and rabbits include poisoning, trapping, shooting, applying repellents, and constructing barriers. The methods best suited for use depend on regional and local conditions. Where the presence of hares or rabbits constitutes a threat to health or a significant economic problem, get the advice of the appropriate command staff entomologist.

Exercises (C15):

Place the letter T before the true statements.

___ 1. Rabbits and hares belong to the order Lagomorpha.
___ 2. Rabbits and hares have two upper incisor teeth rather than four.
___ 3. Hares and rabbits serve as the primary reservoir of tularemia.
___ 4. Rabbits and hares do extensive damage to trees and erosion control plantings.
___ 5. Hares and rabbits are heavily furred animals with long ears and enlongated hind legs.
___ 6. The young rabbits are born in an advanced state with eyes open and the body well-furred.
___ 7. Techniques employed for the control of hares and rabbits include poisoning, trapping, shooting, applying repellents and constructing barriers.

C16. Complete given statements pertaining to the importance of moles.

Importance of Moles (Nonrodent Vertebrate Pests). Moles belong to the order Insectivora, family Talpidae. The general distribution of moles seems to depend largely upon atmospheric humidity and the resulting condition of the soil. They are absent altogether from arid regions, and where the prairies of the middle west merge gradually into the Plains, they live only along watercourses. In these regions of deficient rainfall, the ground is so dry and hard during the greater part of the year as to be wholly unsuited to the existence of earthworms and insect larvae, upon which the mole depends for food. In the east, moles are most abundant in moist, rich soils along streams, particularly if these places are somewhat shaded. In the cooler, more uniform climate of the Pacific Northwest, they are plentiful anywhere in the well-watered valleys.

Moles often disfigure lawns, damage golf courses, and ruin seedbeds in gardens and nurseries. They cause damage in cornfields, gardens, and flowerbeds by eating seed corn and plant roots and also by traveling along the rows, heaving the plants out of the ground, and thus causing heavy crop losses. Mounds raised by moles in hayfields break or quickly dull the knives of the mower cutter bar or else necessitate raising the bar so much as to reduce the crop.

The mole is also a potential carrier of plant pests and diseases, and the mole's work may seriously increase the damage during such outbreaks. In scratching or eating infected bulbs or roots and then going to healthy plants, these animals may spread disease organisms such as the mosaic virus and other bacteria or spores as well as injurious nematodes. One mole can easily travel 100 yards a day through loose soil.

Exercises (C16):

1. The general distribution of moles depend largely upon the atmospheric ______ and the resulting condition of the ______ .
2. In making their mounds and runways, moles often disfigure ______ , damage ______ ______ and ruin ______ in gardens.
3. The mole is a potential carrier of plant ______ and ______ .

C17. Identify given statements concerning the recognition characters and biology of moles as being correct or incorrect.

Recognition Characters and Biology of Moles. So seldom is the mole seen, even by those familiar with its work, that it is often confused with other small creatures, particularly the shrew, the vole (or meadow mouse), and the pocket gopher. The mole is readily distinguished from the pocket gopher by the absence of cheek pouches and by its less conspicuous eyes. The mole is not a rodent and can be readily distinguished from any of this order and from the shrew by its short, stout, front limbs ending in broad, rounded hands with strong claws and with palms turned outward. It has a rather elongated body, close, plushlike fur, a pointed snout, and a short tail.

Neither external eyes nor ears are ordinarily in evidence. If not totally blind, the common mole of the eastern part of the United States can at best merely distinguish between light and darkness, as what remains of its organs of sight lie wholly beneath the skin. The degeneration of these organs has apparently not proceeded so far in Townsend's mole (the largest mole on the continent), which usually opens its eyes when annoyed by an observer. The eyes of the star-nosed mole also are readily discernible. The mole lives mostly underground. Its experiences come through its sensitive touch, acute hearing, and highly developed sense of smell. While the animal is seldom seen above ground, it sometimes ventures out of its tunnels, chiefly at night.

When a mole is living in lawns, gardens, or fields, telltale ridges or conspicuous mounds of earth plainly indicate its runways. The ridges show the direction and course of the animal's hunting paths, which are so close to the surface that the sod or the soil crust is raised. The mounds indicate deeper tunneling. Such mounds thickly dot the mole-infested area of the Pacific coast country. They are of much rarer occurrence in the habitat of the common eastern species, but the star-nosed mole regularly uses this method to dispose of dirt from its tunnels.

The number of mounds or ridges in a field does not indicate the number of moles present. One Townsend's mole, for instance, in a period of 77 days constructed 302 mounds on a quarter-acre field.

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The mounds of Townsend's and other moles of the west coast resemble superficially the earth heaps thrown up by pocket gophers, but usually they can be distinguished. The mole heaps are the more rounded and symmetrical and are built up, volcano fashion, by successive upheavals beneath and through the center of the pile. The soil that is thus excavated rolls down the sides from the summit. The pocket gopher, on the other hand, brings up the soil excavated in its workings and dumps it on the surface in armfuls, thus forming low, semicircular or fan-shaped accumulations of fine dirt more or less to one side of the burrow exit.

The more permanent tunnels of the mole commonly run along fences, hedges, walks, plant rows, and the ridges of open fields. These places give the mole some concealment or shelter. These burrows vary in depth from only 1 or 2 inches to levels beneath the reach of the plow. They constitute a labyrinth of runways, apparently constructed with no definite plan and including here and there an enlargement.

A mole's appetite seems to be almost insatiable. When held in captivity and given food to its liking, one will sometimes eat more than its weight in a day. The large quantity of food thus required is no doubt due to the intensely active life the little animal leads. Few other mammals are relatively as strong or do as much hard work in a day. The mole's food generally consists of adult insects and their larvae, and earthworms. For the common eastern mole, earthworms and white grubs constitute the bulk of the food. Beetles and larvae, other ground-inhabiting insects and their cocoons and puparia, spiders, centipedes, and some vegetable matter also are included in the eastern mole's diet. Townsend's mole also lives largely on earthworms and larval and adult insects, but it takes a considerably greater quantity of vegetable matter than does the eastern mole. As the mole's short teeth are not well suited to gnawing, damaged roots are managled but not cut clean.

Moles probably never become dormant. They extend their surface runways, however, mainly at times when soil conditions are favorable—after rains in summer or during periods of thaw in winter. At other times in their search for food, moles must use their old runs or work at depths and in situations unaffected by frost or drought. Movements of soil-inhabiting worms and insects, including larvae, tend to bring ever fresh supplies of food into these tunnels.

Contrary to popular opinion, moles are slow breeders. Their life of seclusion shelters them from many dangers. To maintain their normal numbers from generation to generation, a rapid rate of increase, therefore, it is not necessary. Moles grow and develop with surprising rapidity. For example, in the

Northwest, most of the young are born in the latter half of March and the first half of April, spend about a month in the nests, and early in June are so well grown as not ordinarily to be distinguished from the parent moles. This rapid growth accounts for the fact that small young moles are seldom trapped. By the time they leave the home nest and take to the runways for themselves, they already have attained something like the size and proportions of adults.

Exercises (C17):

1. Place the letter "T" before the true statements..

___ a. The mole is a rodent.
___ b. The mole has short, stout, front limbs ending in broad rounded hands with strong claws and with palms turned outward.
___ c. If not totally blind, the common mole of the eastern part of the United States can at best merely distinguish between light and darkness.
___ d. The mole lives mostly underground.
___ e. The mounds show the direction and course of the animal's hunting paths, which are so close to the surface that the sod or the soil crust is raised.
___ f. A mole's appetite seems to be almost insatiable.
___ g. A mole's food generally consists of adult insects and their larvae and earthworms.
___ h. Moles grow and develop with surprising rapidity.

2. Correct the false statements.

C18. State how you should inspect for the presence and population of moles.

Inspection Methods. No special inspection methods apply to determining the presence of moles. Their presence is evident from their digging. The only way you can take a population survey is to observe their activity.

If you make an opening in a mole's runway, the animal will repair the hole when it next comes that way. By taking advantage of this habit, you can gain much information if you will visit, at short intervals through the day, each of a number of runs in which you have made a small break. You are as likely to find moles working at one hour of the day or night as at another, especially in seasons when there is no great variation in temperature throughout the 24 hour day.

Exercises (C18):

1. How can you determine the presence of moles?

2. State the inspection methods you should use for population surveys.

C19. Complete given statements concerning mole control.

Control. You can control moles by limiting their food; by trapping, drowning or gassing; by using repellents; and, to some extent, by constructing barriers.

Food control. The control of moles in lawns and other turf areas can be achieved effectively, though indirectly, by the application of insecticides. Such treatments control beetle grubs and other lawn insects, thereby depriving the moles of their natural food supply. The moles are not affected directly by the insecticides in the dosages used, but they remain out of the area because of the absence of food. Specific dosage recommendations for various insecticides are given in Appendix A of the supplement to Volumes 4, 5, 6, and 7.

Trapping. Trapping is a universally applicable and satisfactory method of mole control, but it is successful only if the habits and instincts of the mole are considered carefully. The suspicion of the mole, for instance, is aroused when its sensitive nose encounters anything foreign in its runway, and it will immediately back up and burrow around or under an ordinary trap set in its tunnel. It is not suspicious of dirt blocking the runway, however, as its burrow is closed frequently by farm machinery and by people and large animals stepping on it. The mole will immediately push its way into such a dirt blockade, reopen it, and continue on its way.

This habit provides opportunities for using a specially designed trap that straddles, encircles, or is held suspended above the runway, the trigger pan resting on or hidden in a dirt blockade. Under such conditions, the unsuspecting mole cannot detect the presence of the trap. In pushing into the dirt obstruction, it either lifts the trigger pan or pushes the dirt against the hidden trigger arm and thus releases the trap spring.

Another fundamental condition for you to remember is that the mole is sensitive to an unnatural environment. For this reason, you should never tear up large or numerous sections of the mole burrow in attempting to locate a favorable setting for a trap. You also should bear in mind that a poorly set trap is a detour sign for the ever-suspicious mole. The selection of a frequently used runway for a trap set is of prime importance.

East of the Rocky Mountains, place the traps in the hunting tunnels, which are close to the surface and are indicated by the conspicuous ridges. These surface runways are made for the primary purpose of finding food. Many of them are, therefore, not used more than once; others, however, serve as highways and are used regularly. Ordinarily, a runway that takes a straight course for some distance or seems to connect two systems of workings will be in constant use. You often can determine the used tunnels by poking a small hole into all tunnels in the area and noting later, usually within a few hours, which ones have been closed. In large fields you can find the runs in use by driving a vehicle back and forth across the area, flattening the mole ridges at intervals of 50 to 100 feet. The following day the regularly used runways will be raised again. When you can locate the deeper runs, which often are highways used by many moles, you can catch a number of moles by continued use of traps in the same place. Such deep tunnels are usually 3 to 12 inches or more below the surface, along fence lines or ridges in open fields, or at crossings from sodded to cultivated ground.

In such cases, an entire 6-acre field can be treated successfully by setting traps along the fence rows. As moles are active throughout the year, they may be trapped at any season, although it is not practical to carry on operations when the ground is frozen or exceedingly dry. The best time to trap is when fresh signs of mole activity are noted.

The large moles of coastal Washington, Oregon, and California *(Scapanus spp.)* differ in habits from the common moles east of the Rocky Mountains in that they push to the surface numerous piles of earth (mole hills), indicating the approximate location of the deeper burrows. This habit makes it feasible to trap them in the deeper, main-traveled tunnels.

To locate the runway, use a probe or slender metal rod 3½ or 4 feet long and about 3/8 inch in diameter, such as an end-gate rod, or a piece of 1/4-inch gas pipe. Push the probe into the soil 3 or 4 inches away from a selected mound. If you are directly over the runway, you will feel a sudden give as the rod breaks into the tunnel opening. If not, move the rod to either side, and repeat the probing process at 2-inch intervals around the mound until you break through into the runway. You can probe further at intervals of a foot or so from the mound to determine the direction of the tunnel.

Mole traps on the market are of two general types, the gripping and the harpoon. Gripping traps come in several designs, including the choker-loop trap, the scissors-jaw trap, and the diamond-jaw trap. All are about equally effective. The harpoon trap is more popular than traps of the gripper type because it is set more easily. It is somewhat less efficient, however, because the mole may escape if the prongs do not strike a vital spot.

To use the harpoon trap, pack down the runway ridge with your foot and push the set trap (with safety catch in place) into the ground so that the trigger pan rests snugly in the depressed ridge and the two pointed supports straddle the runway evenly. Then release the safety catch. If the ground is hard or gravelly, spring the trap once to make sure that the impaling spikes or prongs easily penetrate into the soil for their full length. If they do, reset the trap without changing its position; if not, select a new place.

To set a gripper trap, make an excavation across the burrow a little deeper than the burrow, just the width of the trap. A garden trowel is useful for this purpose. Note the exact direction of the tunnel from the opened ends, and place the set trap so that its jaws evenly straddle, or its loop encircles, this line of course. Then block the excavated section with loose, damp soil from which you have removed all gravel and rubbish. Pack the soil firmly underneath the trigger pan with your fingers and set the trap so that the trigger rests snugly on the built-up soil; omit this step when you use the diamond-jaw trap. Finally, fill the trap hole with enough loose dirt to cover the trap level with the trigger pan and to exclude all light from the mole burrow. The mole in forcing its way through the soil blockade will be certain to spring the trap by raising the trigger pan (of the choker-loop or scissors-jaw trap) or by moving it to one side (if you use the diamond-jaw trap). Choker-loop and diamond-jaw traps, both of the gripper type, may be set successfully in loose, mellow, damp soils without making an excavation by following the method described for setting the harpoon trap.

Drowning. Moles may be drowned out by flooding the runways, especially during April, when the young are most likely to be in the nest and cannot escape the water.

Gassing. Gassing has been given increased attention in recent years, following the development of highly toxic and easily applied compounds. Calcium cyanide dust or carbon disulphide in a gaseous form pumped into the runway may destroy the moles under certain conditions or may cause them to avoid the gassed areas. The method is not very dependable, and the cost often is greater than the results justify.

Repellents. The marked tendency of the mole to avoid obnoxious or injurious substances often makes the use of repellents practical in small restricted areas of lawns or gardens. Lye, paradichlorobenzene, and napthalene are effective. Open the visible mole runways with your finger or a small stick. Insert a teaspoonful of one of these materials and close the opening carefully. Make applications at intervals of 8 to 10 feet along the raised runways and should be repeated whenever sections of old runways show signs of being in use or when any new ridges appear. Fencing small areas with woven wire or with concrete is sometimes practicable where valuable plants require special protection against eastern moles.

Barriers. Galvanized hardware cloth with 4 meshes to the inch for excluding mice as well as moles will last a number of years, but concrete walls 1 inch or more thick have been found cheaper in the long run. Fencing alone, however, cannot always be depended upon, and it may be necessary to supplement this method of control by trapping.

Baits. Appendix A of the supplement to Volumes 4, 5, 6, and 7 provides information pertaining to the type of poison bait that can be used in the control of moles (listed under "Rodenticides") and also outlines the preparation and application rates and methods.

Exercises (C19):

1. Moles can be controlled by controlling their ______; by ______, ______, or ______; by using ______.
2. The control of moles in lawns and other turf areas can be achieved effectively by limiting their food by applying ______.
3. The mole is most sensitive to an ______ environment.
4. The surface runways are primarily for the purpose of finding ______.
5. Mole traps on the market are of two general types, the ______ and the ______.
6. Moles can be drowned out by flooding the ______ especially during April.
7. Gassing is not very dependable, and the ______ often is greater than the results justify.
8. Effective repellents are paradichlorobenzene, ______ and ______.
9. Fencing small areas with ______ or with ______ is sometimes a practical method of controlling moles.
10. In Appendix A of supplement to Volumes 4, 5, 6, and 7 the pesticide listed to be used for bait for moles is ______.
11. Three gripper traps are ______ ______ and ______.
12. The type of trap that is easier to set is the ______ trap.
13. To set a gripper trap, you must make a ______ blockade.

C20. Identify given statements pertaining to the importance, recognition characters, biology, and control of shrews, as being true or false.

Shrews belong to the family Soricidae of the order Insectivora. They occur nearly worldwide. The most common species inhabiting the eastern half of North America is the short-tailed shrew, *Blarina brevicauda*.

Importance. Short-tailed shrews are unique in that they have a poisonous substance in their salivary glands. When they attack their prey, such as mice, the poison enters the blood stream of the victim and causes partial paralysis. In the case of humans, the bite is not considered particularly dangerous, although it causes a burning sensation and shooting pains that may last for several hours or days.

Shrews are highly beneficial in that they help to control insects, mice, and other forms of life that may at times be objectionable to human interest. They are not known to transmit any diseases of importance to humans or other animals.

They may cause some damage by eating a relatively few tree seeds on certain reforestation projects. Although at times they also eat small amounts of vegetable matter, it is doubtful whether any appreciable injury to gardens or crops can be attributed to them. Such injury is most often caused by the mice that frequent the same runways. Shrews may occasionally wander into buildings where they are unwanted.

Recognition Characters and Biology. Shrews can be readily distinguished from mice. They have a more streamlined appearance and smoother fur. They have minute eyes and long, pointed snouts. Their anterior teeth are not differentiated by form into incisors, canines, and premolars. Their poorly developed, small, black eyes are probably only capable of distinguishing night from day. External ear openings are concealed by fur.

The shrews found in this country are smaller than moles, and they lack the large, paddlelike, digging front feet characteristic of the moles. Shrews prefer to live in woods, swamps, or grassy meadows adjacent to streams. They often make their homes under fallen logs, tree stumps, rock piles, or in rank grass.

Some forms are aquatic, and have stiff hairs lining the toes. Shrews frequently utilize the tunnels and trails of pine or meadow mice. On rare occasions, they may inadvertently enter places of human habitation, usually through cracks and other openings in foundations near ground level.

The animals are extremely active and very belligerent. Their high metabolic rate requires a tremendous amount of energy, and they must eat frequently in order to sustain life. The diet consists almost entirely of animal food, particularly insects, earthworms, snails, salamanders, etc. They are entirely fearless and do not hesitate to attack snakes, birds, or mice much larger than themselves. They sometimes eat roots, nuts, seeds, and fruits, particularly during winter months. They do not hibernate.

Some shrews possess scent glands that emit a disagreeable secretion that discourages predators. In addition to anal glands, they have cutaneous side glands which actively secrete during breeding seasons.

They breed throughout the year, with peaks during the spring and fall seasons. There may be several litters annually of one to ten young in each. The young usually reach adult size in 4 to 6 weeks and mate when approximately 3 months old.

Control. As shrews are beneficial in most situations, controls rarely are applied. However, if control is indicated, shrews are easily trapped with small mousetraps set in runways and near holes. Meat baits are most generally successful.

Exercises (C20):

Identify these statements as true or false. Correct any that are false.

___ 1. Shrews belong to the family Insectivora.

___ 2. Shrews are found only in the midwest.

___ 3. Shrews are more beneficial than harmful.

___ 4. The short-tailed shrew is poisonous.

___ 5. Shrews help to control insects and mice.

___ 6. Shrews can hardly be distinguished from mice.

___ 7. Shrews usually live where humans live.

___ 8. Shrews are very active and very belligerent.

___ 9. Shrews will attack snakes or mice much larger than themselves.

___ 10. Shrews breed only in the fall.

___ 11. Shrews cannot swim.

___ 12. Controls are rarely applied to shrews.

C21. Complete given statements concerning the importance and control of predatory animals.

Importance and Control of Predatory Animals. On large military reservations, coyotes (or prairie wolves), foxes, and other predators may find sanctuary. They may leave and go to neighboring farms and grazing areas to destroy game, beneficial wildlife, and domestic animals. Sometimes, these animals are reservoirs for rabies and may be responsible for its spread. At times, these animals damage aircraft arresting barriers and can present serious hazards to aircraft.

Predatory animals can be controlled through the use of traps and poison baits; however, they should not be killed without prior approval of the command entomologist. The assistance of the entomologist and specialists from the Department of the Interior, Fish and Wildlife Service, should be obtained for the control of these animals. When rabies or other diseases are present, you should get help from the State health authorities.

Exercises (C21):

1. Coyotes, ______, and other predators may be found on large military reservations.
2. Predators, such as coyotes, are reservoirs for ______.
3. At times animals ______ aircraft arresting barriers.
4. Predatory animals can be controlled with ______ and poison baits.
5. When rabies is present on base, as an entomology specialist, you should get help from the ______ ______ ______.

1-4. Domestic Animals

You will sometimes be called on to control domestic animals that have been permitted to run loose and breed. These animals can be a serious health hazard to other animals on base as well as to people.

C22. Identify as true or false given statements pertaining to the importance and control of domestic animals.

Importance and Control of Domestic Animals. Domestic animals, such as dogs, cats, and horses play an important role in almost everyone's life. Almost every housing unit on Air Force installations has at least one dog or cat and often there will be more than one per unit. As for horses, almost every large Air Force installation has a riding stable so that Air Force members can enjoy horseback riding.

As long as these animals are properly controlled by the respective owners, they present no problems, but when dogs and cats are allowed to roam freely throughout the base uncontrollable multiplication results. When these situations occur, you have an overabundance of semiwild animals. Thus, there is an increased potential of rabies in the animals on base. The animals in an uncontrolled state can transmit rabies to humans. These same animals serve as hosts to the medically important ectoparasites such as fleas, ticks, and mites.

The owners of the domestic animals have the overall responsibility for controlling their pets. Owners should confine their pets by fencing, leashing, or keeping them indoors. They must insure that the pets have been innoculated against rabies and that innoculations are current.

When the owners do not meet the requirements and responsibilities for controlling their pets, the security police must become involved. Security police personnel may catch or shoot the animals.

Since you have a responsibility for controlling pests on Air Force installations, you may be required to rid an area of stray dogs and cats. This task may be accomplished by using traps and, in extreme situations, using poison baits and fumigants.

Before you implement any control measure that might injure the animals, be sure that you have obtained proper approval through the chain of command.

Exercises (C22):

Indicate whether each statement is true or false. Correct any false statements.

___ 1. When stray animals are a problem, use any means you feel necessary to control them.

___ 2. Almost every large Air Force base has a riding stable.

___ 3. The average military housing unit has at least one domestic animal

___ 4. Domestic animals allowed to run loose on base can transmit rabies, but that is the only real problem.

___ 5. Animal owners have the responsibility of controlling their pets and insuring that they have been innoculated.

___ 6. The entomology specialist should use traps to control stray dogs and cats. Only in extreme cases should he use poison bait.

1-5. Bats

Although bats are mammals, their habits, their importance, and the applicable control methods are quite different from those of the mammals you have already studied. This section gives you information pertaining to the importance, recognition characters, biology, inspection, and control of bats.

C23. List the undesirable characteristics of bats and state their one beneficial feature.

Bats belong to the order Chiroptera. They are found nearly all over the world. Of 2000 species, about 65 live in the United States. Occasionally, the presence of these animals creates a problem for military pest controllers.

Importance. Bats are relatively harmless animals in themselves and may be considered beneficial through their control of insects. But, from a medical standpoint, bats are reservoirs (and occasionally vectors) of such serious human diseases as rabies, relapsing fever *(Borrelia sp.)*, Japanese "B" encephalitis, Chagas' disease, dermatomycoses, and histoplasmosis.

Bats have many parasites, and most of these will feed on humans. Some of their common parasites are: argasid ticks; mites in at least four families; bedbugs; bat bugs; and "bat ticks," which are flies adapted for parasitism.

When bats invade homes or buildings, they become nuisances and require control. Bats normally roost in natural shelters, such as caves and hollow trees. Some, however, live in attics, spaces between walls, or any unused, darkened areas well above ground. From these places, Their parasites move to attack people. When bats are present in large numbers, they create an almost overwhelming ammonia odor resulting from urination and defecation. The odor persists for a long time after the roost is broken up. The sounds caused by these sometimes restless, crawling animals is often disturbing to human occupants. While bats cause no actual damage to structures, their presence is undesirable.

Exercises (C23):

1. List the undesirable characteristics of bats.

2. What is one benefit we derive from bats?

C24. Distinguish between true and false statements concerning the biology, inspection, and control of bats.

Recognition Characteristics and Biology. Bats are small, fur-bearing mammals with a thin, leathery or membranous skin that stretches between the greatly elongated bones of the front legs and "fingers." They are the only mammals thus equipped to fly. Species in the United States are small, averaging 5.0 to 12.7 cm in body length, with a wingspread of 25.4 to 38.0 cm.

They are nocturnal animals, leaving their roosting places at dusk to fly about in pursuit of the night-flying insects that provide the bulk of their food. By day, they roost in dark, sheltered places.

A few species are solitary, but most congregate in groups or in colonies, the largest of which may number a million animals or more. Some bats migrate with the change of seasons, following a steady source of food supply.

In the temperate regions, the young bats are born in the late spring. In the tropics, there appears to be no definite breeding season, and young may be found in

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every month of the year, though most females bear but one offspring per year.

Most bats feed almost entirely on insects, and some species have been reported to consume from one-half to their full body weight in insects per day. A few species feed on fruits, nectar, and fish, and some (vampire bats) feed on blood.

Inspection. You can observe bats easily when they are flying at dusk. You can find roosting locations by looking for great numbers of bats beginning their evening flight. You can determine the presence of bats in buildings by the odor created or by the scratching and squeaking noise made as the bats begin and end their nocturnal flights.

Control. In many cases, you can control bats through the use of napthalene or paradichlorobenzene, two compounds used as insect repellants. Three to 5 pounds of napthalene flakes scattered liberally over the entire area should treat the average attic. The odor is apparently extremely offensive to the bats because they begin to leave immediately in broad daylight. In large areas with free ventilation to the outside, both compounds dissipate rapidly; therefore, you must replenish them at frequent intervals.

Another effective repellant combines oils of mustard and sassafras with an emulsifier and water. Spray this mixture on all roosting sites. It is usually good for several months. You can prepare the repellent by mixing one part each of the two oils and the emulsifier with 97 parts of water.

Bats are quite persistent, and it is often difficult to dislodge all members of the colony from an old, established roost. Also, new bats are attracted by the odors left by the recently departed guests. For this reason, batproofing is an extremely worthwhile measure following the use of repellents.

Bats may enter buildings through such openings as unprotected louvres or vents, broken windows and siding, and around eaves or cornices. The smaller species of bats can crawl through an opening as small as 3/8 inch. The larger openings should be covered with sheet metal or with 1/4-inch mesh hardware cloth if ventilation is necessary. It is essential that no openings larger than 1/4 inch be left. Plug narrow cracks with oakum, tow, or similar packing material and seal them with caulking compound. Inspect all old siding and baseboards to make certain that you haven't overlooked any alternate entrances. Be sure that all bats are out of the building before you complete the exclusion measures. Normally, during the warmer months when bats are active, all of the bats leave their roost within 15 to 20 minutes after the first one starts out. If they have been disturbed, however, their normal routine may be upset. Thus, you should leave open one or two of the most used openings temporarily. After the last bat has left the roost for feeding, close the remaining openings. If a number of entrances have been used, let 2 or 3 days elapse before you close the last entrance in order to allow all the bats to learn to use this last opening. If you have overlooked any entrances, the bats soon will find them. For this reason, you must watch the building closely at dusk for several evenings to see whether the bats gain entrance through any overlooked holes.

In cases in which repellents and batproofing do not prove satisfactory, you may have to destroy the bats by fumigating their roost. It should be emphasized that there are several disadvantages connected with this type of control. The cost of time and labor may be high to control a small number of animals. Another disadvantage is that the gas kills the bats as they hang in repose, you can't retrieve many carcasses. These bodies decompose, giving an offensive odor. Finally, fumigation gives no lasting control. As soon as the gas has dissipated, the roost is ready for occupancy once again. Batproofing should immediately follow fumigation.

If you have received approval from the command entomologist, you can apply DDT in the roost area that will kill bats after 2 to 3 weeks exposure. You can apply it as a dust or a spray. One pound of the 75-percent wet-table powder per gallon of water makes a suspension suitable for use. It is important that the treatment be thorough and that you spray or dust all entrances and exits.

Exercises (C24):

Indicate whether the following statements are true or false. Correct any false statements.

___ 1. Bats are small, fur-bearing mammals.

___ 2. Bats leave their roosting places at dawn in pursuit of food.

___ 3. When you inspect for bats, you can see them easily at dusk as they fly.

___ 4. It is easy to dislodge all members of a bat colony from an established roost.

___ 5. Bats can be controlled by using some insect repellants.

___ 6. Fumigation of bats gives lasting control.

___ 7. Bats are one of the few mammals equipped to fly.

___ 8. Most bats feed on blood.

___ 9. The odor of napthalene offends bats.

___ 10. A new colony of bats is usually repelled by the odor of other bats in a roosting place.

___ 11. DDT will kill bats.

1-6. Pest/Hazardous Bird Species

East year the U.S. Air Force loses millions of dollars and hundreds of work-hours in maintenance because of damage to aircraft and equipment caused by birds. These losses result from bird strikes to aircraft and from bird droppings and nesting materials in and around air base structures and equipment. The seriousness of this problem and the potential health hazards caused by birds in certain situations require pest bird management procedures for each airdrome environment. Bird control in the airdrome environment can be a complex problem. However, simple procedures often can be started and continued on a regular basis to greatly reduce pest bird problems.

People have always been fascinated with birds, particularly with their ability to fly. This fascination did not lead to an understanding of birds and their importance until recent times. Even when birds were recognized as an important food source, we hunted some species so extensively that we contributed to their elimination. Our failure to understand the role that birds play in nature also has destroyed their habitat and damaged the environment to the extent that some species have been eradicated totally, while others are near extinction. At the same time, some species have either benefited from habitat changes or have adapted to living near humans. Many of these species multiplied, and some that formerly were limited in their range are now found nearly worldwide. As the importance of birds became apparent and we began to understand our impact on birds and their populations, the protection and management of birds gained new emphasis. Laws, treaties, and regulations were established to protect birds and to ensure that they would be maintained as important natural resources. At first these laws concerned only game species, but now almost all of the birds in North America are protected by a number of laws, treaties, and regulations. The pest manager (PM) must be aware of the legal protection that has been given to birds. Any bird control program must comply with applicable regulations and should be coordinated with the appropriate local, State, and Federal wildlife authorities.

The information contained herein provides background information needed by a base PM to contain or eliminate real or potential pest bird problems. Each PM should know and understand the basic principles of bird biology and behavior as they affect bird control and to choose the most appropriate control technique for the situation at hand.

C25. Define given terms relating to effective bird management.

Definition of Terms. The following terms are used in relation to effective bird management.

Bird damage. Bird damage results when material or equipment is damaged as a result of bird activities. There is a distinct difference between a bird nuisance and bird damage. For example, a few noisy house sparrows around an office building may appear to be a problem, but only may be an annoyance to workers. Bird damage occurs when the sparrows build nests in the building, leaving corrosive droppings or holes in screening.

Bird damage control. Bird damage control seeks to reduce the potential for damage caused by birds. Bird hazard control attempts to reduce the health or safety hazard potential. The term "bird control" sometimes includes the control of both damage and hazards. The objective, however, is to reduce the damage and the hazards that birds can cause, rather than to control the birds.

Bird hazard. A bird hazard exists when birds represent a potential threat to health or safety. Concentration should be emphasized on bird hazards, rather than bird damage. In and near an airdrome the bird/aircraft strike hazard is frequently serious, and reducing this hazard becomes the most important task of the PM.

Bird management. Bird management depends on changing the characteristics and interactions of birds, habitat, and man to achieve human goals. It refers to everything man does deliberately to affect birds, whether to encourage or discourage them from a given area, or to increase or decrease their populations.

Bird strike. Bird strikes (contact between a bird and a moving aircraft) causes losses of lives and equipment, with even minor bird strikes resulting in thousands of dollars in annual repair costs. Bird strike hazards also can interrupt base missions. Aircraft collisions with birds are the most serious problem. Bird/aircraft strike problems can occur during the takeoff, en route or landing phases of flight and are hazardous particularly during the low-level phase. The hazards during takeoff and landing are the main concern of the PM. Therefore, control of bird activity on or near the airfield is your responsibility.

Pest bird. A given bird may be beneficial or injurious to man's interests, depending on its activities at a specific time and place. The term "pest bird" refers to an individual, flock, or population causing economic damage or creating a health or safety hazard by its activities at a given time and place. Certain species may become involved in hazardous or damaging situations more frequently than others because of their behavior patterns or habitat requirements.

Exercise (C25):

1. Match given definitions with the appropriate term. Some definitions may not be defined, and there is only one "best" match for each term.

C4

Column A

____ (1) Any bird that is causing damage or creating a hazard by its specific activity.

____ (2) A danger to health or safety caused by birds.

____ (3) Economic loss caused by pest birds.

____ (4) Anything done deliberately to affect birds.

____ (5) Bird management in which the specific goal is to minimize the potential for damage.

____ (6) Any contact between a bird and a moving aircraft

Column B

a. Bird control.
b. Bird damage.
c. Bird damage control
d. Bird hazard.
e. Bird hazard control.
f. Bird management.
g. Bird management.
h. Pest bird.

C25a (C37 — for CE feedback reference only). Identify as true and false given statements pert aining to bird habits which conflict with man, and feeding habits of various bird species; amend the false statements.

Bird Habitat. Each bird species has habitat requirements which determine where the bird will nest, roost, and feed. Pest bird problems often result from environmental situations which produce attractive habitats for large bird populations of a single species (a building with abundant roosting area for pigeons), or habitat that attracts large bird populations of different species (carelessly harvested grain crops attracting large flocks of blackbirds and starlings). Marshes, pine plantations, grasslands, and wooded areas are examples of natural habitats. Buildings with accessible girders, short grass on an airfield, and ornamental trees planted close together are examples of manmade habitats. You must learn to recognize these conditions. The advice of local wildlife authorities or State and Federal agencies often can be helpful in assessing these situations.

Roosting. A roost is where birds congregate at night, in bad weather, or at other times when they are not feeding. You usually will be concerned with birds that roost in large flocks. Gulls that roost on the ground during the day or night can become pest problems as can large flocks of blackbirds, swallows, or other small birds that roost usually in large concentrations during the night. The areas where birds, such as gulls, ducks, and geese, roost during daylight hours when they are inactive are called loafing areas. The type of habitat chosen for roosting depends on the habitat preference of the birds. The roost site usually provides protection from weather and predators. Plantings, such as ornamental evergreens around buildings, often provide shelters and become roosting sites. Short grass on the airfield offers the birds protection from predators by allowing an unobstructed field of vision. Such situations often can be controlled with appropriate grounds maintenance procedures. Even if the roosting site is some distance away from potential bird strike hazards, the pathway birds use to enter or leave the roost may create a problem. In such a case, reducing the attractiveness of the roost site is more effective than trying to alter the routes that birds use to enter or leave the roost. Species that typically roost on or in manmade structures are of particular concern. Domestic pigeons, starlings, and house sparrows find suitable roosting areas on ledges, rafters, and other structures that give them protection from harsh weather and predators. The latter two species also will roost or nest in enclosures of aircraft. Whenever possible, you should reduce the attractiveness of such roosting areas to these birds.

Feeding. If a food source is related directly to bird control problems, control of the food source may be easier and more effective than direct control of the birds. Food and feeding habits of birds vary with species, season, and availability of particular food items. Several terms describe birds according to the type of food that they consume. An insectivorous bird, such as a swallow, feeds primarily on insects. Carnivorous birds, such as hawks or owls, are meat-eaters, feeding mainly on other birds, mammals, reptiles, amphibians, or fish. A herbivorous bird, such as a dove, feeds on plant material. A herbivore that feeds mainly on seeds and grains often is referred to as granivorous. Many species are omnivorous; that is, they feed on both plant and animal foods. The common crow and starling are good examples of omnivores. Crows consume fruits, grains, insects, young birds or bird eggs, reptiles, frogs, small mammals, carrion, and discarded human food. The starling, which feed on insects, fruits, grains, and seeds, also is known for feeding on garbage in and around towns and cities. Gulls are also a well-known omnivorous species.

Several of these terms may apply to a single species, depending on time of year or food availability. For example, during the nesting season the diet of red-winged blackbirds consists largely of insects while during the winter months they are granivorous. If weed seed availability is good, red-winged blackbirds consume large quantities of ragweed, bristle-grass, panic grass, or other seeds during the summer. This feeding habit makes these birds beneficial to farmers during the summer months. In addition to weed seeds, however, they often consume large quantities of corn, oats, wheat, sunflowers, barley, and rice, thus becoming farm pests.

Some species are referred to as scavengers. These birds feed on the remains of plants and animals. Carrion eaters such as vultures are scavengers, as are those omnivores that feed on dead plants and animals and on garbage. Gulls and crows associated with garbage dumps and landfills are scavengers and can become serious pests when dumps and landfills are located near airfields.

Feeding flocks or individual birds may pose a bird/aircraft strike hazard. Species that feed on the ground, among vegetation, or on bodies of water may pose a problem as they move to and from a feeding area. Aerial feeders such as swallows can present a pest bird problem when feeding in the airdrome environment. Terns, kingfishers, ospreys, and kestrels can pose a problem because they often hunt their prey by flying or hovering over a feeding area. Knowing the feeding habits of birds may be helpful in determining if a food source is the direct cause of the problem. You must determine carefully if a pest bird species is feeding, since methods used to control feeding flocks may be quite different from those used to control roosting flocks. By direct observation you should be able to determine whether a bird or a flock of birds is feeding, roosting, loafing, or nesting.

Learning. Another important concept of bird behavior is the ability of birds to learn. Learning results from experience, practice, trial, and error. For example, a bird may learn to find food at a certain location through experience; that is, the bird has found food at that location in the past. Furthermore, through practice or through trial and error, the bird may learn how to remove food from a container at that location. Bird species differ in their ability to learn.

Habituation. Habituation is a type of learning defined as the declining response to a simple stimulus because no reward or punishment is associated with the stimulus. Simply, the bird gets so accustomed to a specific condition that it no longer reacts to that condition. A bird initially frightened away by the presence of a human being may soon become tame if the presence of the human being (the stimulus) does not result in any danger.

Habitation is extremely important to you because it can affect many pest control methods. At first, devices used to repel birds with sharp, loud noises are often quite effective. The birds react to the loud noise and are frightened away. After some time, however, the birds' reaction to the noise decreases because they do not associate the noise with any punishment. Using repulsion techniques in conjunction with occasional real danger (such as live ammunition) can prevent birds from becoming habituated to a particular technique. Control techniques will be discussed in length later in this section.

Exercises (C25a):
Indicate each true statement and correct any false ones.

____ 1. Nesting, roosting, and feeding are determined within each bird species by habitat requirements.

____ 2. Short grass on an airfield and ornamental trees planted close together are examples of natural habitats.

____ 3. You, the pest manager, usually will be concerned with birds that roost in small flocks.

____ 4. Roosting habits depends on the habitat preference of the bird species.

____ 5. Short grass on airfields offers bird protection from predators through an unobstructed field of vision.

____ 6. Species of birds that typically roost in or on natural habitats are of particular concern to you.

____ 7. Domestic pigeons will roost or nest in enclosures of aircraft.

____ 8. Control of a food source may be easier and more effective than direct control of the bird if a food source is related directly to the control problem.

____ 9. Food and feeding habits of birds are the same with species, season, and availability of food items.

____ 10. Hawks and owls are well known as carnivorous type birds.

____ 11. During the nesting season, the red-winged blackbirds diet consists largely of grains.

____ 12. The weed seed feeding habits of the red-winged blackbird is beneficial to farmers.

____ 13. Feeding flocks of birds pose no threat as a bird/aircraft strike hazard.

____ 14. Ospreys and kestrels can pose a problem because they hover over a feeding area hunting their prey.

____ 15. A bird's ability to learn is the same in all species.

____ 16. Habituation, a type of learning, is the increasing response to a simple stimulus with no punishment associated with that stimulus.

____ 17. Habituation is extremely important because it can affect pest control methods.

C25b (C38 — for CE feedback reference only). Identify given anatomical parts of birds and match topographical characteristics to a particular bird species.

Importance of Identification. Because of differences in habitat requirements and behavior, various groups and species of birds create different types of pest problems. Birds differ in their response to a given control measure. An effective technique for one species may be useless, or even illegal for controlling another. Thus, it is extremely important to properly identify the birds causing the problem (the target species) before beginning any management or control measures. Proper identification of nontarget species also is necessary to evaluate the potential for undesirable consequences of a bird control measure.

Bird Topography The body of a bird can be divided into logical sections; head, trunk, wings, and tail. Each of these sections has a number of parts with which you must be familiar in order to provide proper bird identification.

Head. The head of a bird includes the neck, bill, forehead, crown, nape, lores, chin, and throat. The dorsal (top) portion of the head and neck is divided into the forehead, crown, and nape. The portion of the head between the base of the bill and an imaginary line between the eyes is the forehead. The top of the head to the base of the skull is the crown. The nape or hindneck is the portion of the neck that lies between the crown and the back. The sides and undersides of the head have four major divisions. The lores are small areas located behind the base of the bill and anterior to (in front of) the eyes. The side of the head from the base of the lower portion of the bill to just behind the eye is the cheek. The chin is the small area that lies between the forks of the base of the lower half of the bill, and the portion of the neck below this area is the throat. This is all well illustrated in figure 1-9.

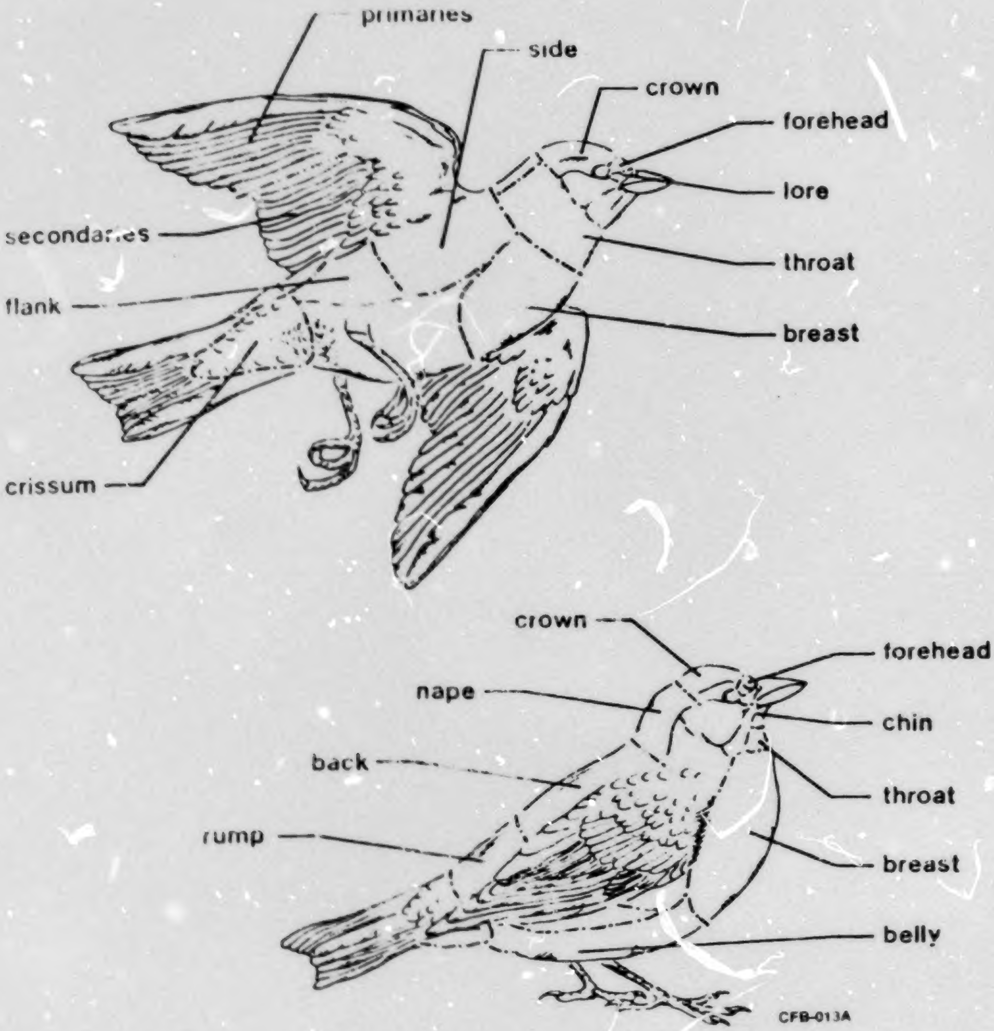

Figure 1-9 Topography of a bird

The bill or beak is often the most notable structure on a bird. By noting the size and shape of a bird's bill, you can learn a great deal about the bird, including the type of food that the bird eats and its mode of feeding. When you use the mode of feeding to aid in the identification of a bird, bill characteristics will be important. You must always observe if the bill is long, short, hooked, curved, wider than it is high, or distinctive in any other way, as shown in figure 1-10. The shape of the bill indicates whether the bird feeds by: (1) probing, as would be indicated by the tubular bills of sandpipers, (2) tearing, as would be indicated by the hooked bill of a hawk, or (3) seed-eating, as would be indicated by the strong conical-shaped bills of many sparrows. In some birds the upper portion of the bill has a prominent fleshy base. This structure is called the cere and is found on birds such as hawks, pigeons, and doves (fig. 1-10). The presence of this structure may help you to identify bird specimens.

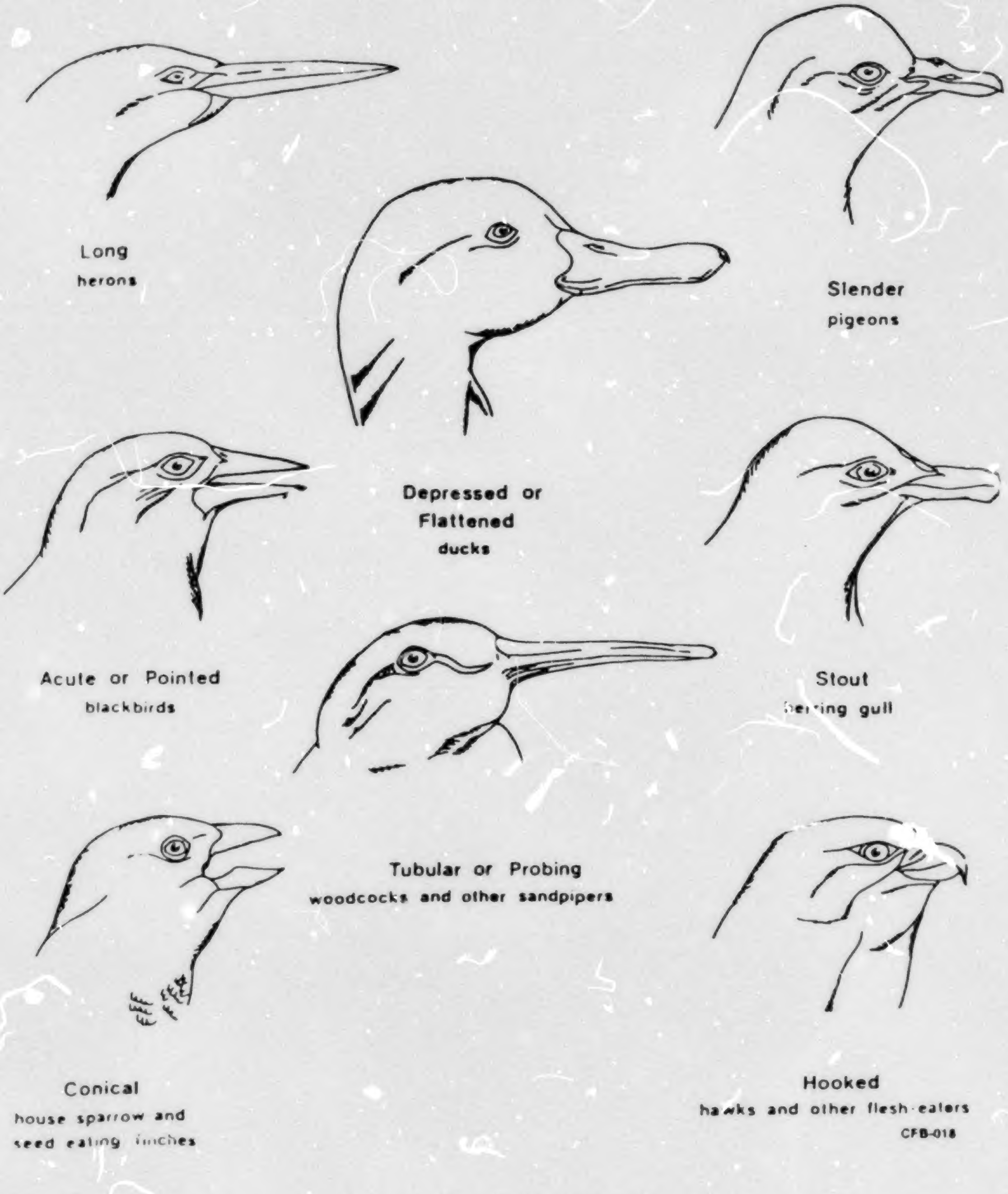
Long
herons
Slender
pigeons
Depressed or Flattened
ducks
Acute or Pointed
blackbirds
Stout
herring gull
Tubular or Probing
woodcocks and other sandpipers
Conical
house sparrow and seed eating finches
Hooked
hawks and other flesh-eaters
CFB-018

Figure 1-10. Typical bird bill shapes

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Trunk. The upper portion of the body or trunk is divided into the back and the rump. The back is the anterior two-thirds of the upper portion of the trunk. The rump is the remaining area extending from the back to the base of the tail. The under part of the bird's trunk is divided into the breast, abdomen, sides, and flanks. The sides and flanks are the areas just under the wings. The breast is the anterior rounded portion of the underside, while the abdomen or belly is the flatter portion around and between the legs of the bird.

Wings. Although the wing feathers of a bird are divided into many groups, only a few feather groups or wing areas are used repeatedly in bird identification. These feathers or areas include the primaries, secondaries, speculum, coverts, scapulars, and wing linings. The flight feathers are composed of the primary and secondary feathers. The primary feathers are those longer feathers composing the end of the wing which allow the bid to fly forward. These feathers are attached to the manus (hand) of the bird. The secondary feathers are the inner flight feathers and are responsible mainly for lift, acting with the forward portion of the wing much like an airplane wing. These feathers are attached to the ulna (forearm) of the wing. Often the secondary feathers of birds, such as ducks, have a color-patterned area known as the speculum. The majority of the smaller feathers on the wing are known as coverts. Covert feathers overlie the base of the primaries and secondaries and cover the remainder of the wing. The feathers of the shoulder area are covert feathers known as the scapulars. The wing lining consists of the covert feathers on the underside of the wing. On the upper surface of the wing, the edges of the scapulars or a row of coverts often are tipped with a color that is different from the surrounding feathers and will appear as wingbars as the bird is sitting. A wing stripe also can be seen in some birds when the bases of the secondary and/or primary feathers are lighter in color than the tips of the feathers. Noting the shape of a bird's wings also can help identify a bird species. Typical wing shapes are illustrated in figure 1-11.

Tail. The tail of a bird consists of the prominent tail feathers and the tail coverts. The large, conspicuous flight feathers of the tail are used as a rudder to steer and when spread act as a brake to slow the bird's flight. Tail shapes vary and can be used as identifying characters (fig. 1-11). Some birds may have colored spots near the tips of the outermost tail feathers, and these tail spots often are used in identification. The upper tail coverts lie above the base of the tail feathers and are not distinguished easily from the rump. The under tail coverts are located at the base of the underside of the tail and are known collectively as the crissum

Legs and feet. Noting the shape, size, and color of birds' legs and feet can be useful in field identification of some larger birds. Although these structures are difficult sometimes to determine as field marks on smaller birds, the legs and feet help identify in-hand birds. Scale and webbing patterns, shape of leg cross sections, toe placement, and the shape of the nail or claw are all important identifying characters. Often bird remains can be identified using only the foot of the bird.

Common Pest Birds. In order to identify common pest birds and select effective control measures, the following descriptions and characteristics should be carefully noted. The most troublesome pest birds are gulls, pigeons and rockdoves, house sparrows, starlings, and various types of blackbirds.

Gulls. Gulls are a group of large shore birds with long pointed wings, usually square tails, strong hooked bills, and webbed feet. Many species are similar in appearance, and field identification requires practice. You should note carefully field marks such as leg color, color patterns on back, head, and wing tips, and the size of the bird relative to a known species.

Domestic pigeon or rockdove. The domestic pigeon apparently developed from the rock dove of Europe, Asia, and Africa and was introduced to this country as a domestic bird. Its rapid growth gave rise to the wild (or feral) populations. The habitat of the wild pigeons was rocky cliffs; the artificial cliffs created by buildings provide appropriate habitat for the feral pigeons. They are almost entirely dependent on the habitat humans have built. Domestic pigeons are a common bird of towns, cities, farmyards, and other areas. Pigeons of North America vary greatly in color and even in size. Various color patterns of gray, black, white, and brown are common. Most types are plump birds with pointed wings and a square tail. Pigeon activities frequently conflict with our interests.

House sparrow. This particular bird, often called the English sparrow, is not a true sparrow; but is a small weaver finch introduced from Europe into North America. The house sparrow is very aggressive, has very few natural enemies and has found abundant habitat associated with buildings and other manmade structures. Its messy habits are objectionable, and this species has outmaneuvered more desirable native songbirds for the available habitat. Adult males have a gray crow, black chin and upper throat, light gray lower breast and belly, white cheek, and brown back and wings. Females and immature birds are dull brown with a tan stripe above the eye.

Starling. Starlings, another introduced species, are similar somewhat to the blackbirds with which it often roosts and flocks. Spring birds have a bright yellow bill and a green and purple iridescence to their dark plumage. In fall the adult plumage becomes spotted with white, and the bill turns dark gray. The short tail and pointed wings are good field marks, especially for the drab, gray, immature birds. Because of the absence of natural enemies and other natural checks, the starling has increased rapidly. This adaptable and aggressive bird has prevailed over native birds in the struggle for available habitat and has found abundant nesting and roosting sites in our cities, where its presence in large numbers is likely to be objectionable. Large wintering flocks also are frequent pests at livestock and poultry feed lots.

Red-winged blackbird. The adult male red-winged blackbird is identified readily by the bright red covert feathers edged in yellow on a totally black body. Females are brown, heavily streaked, and spotted. Immature

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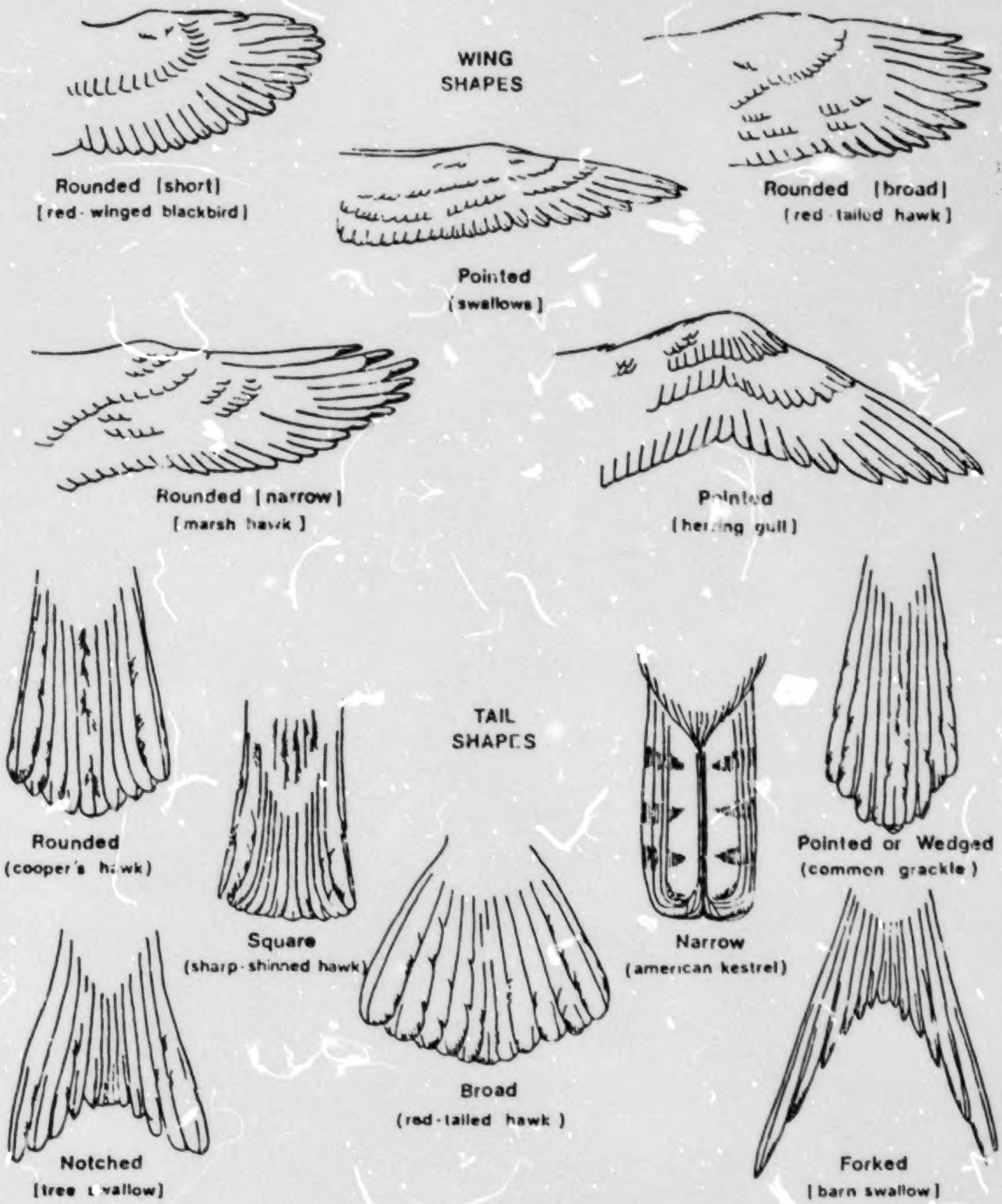
WING SHAPES
Rounded [short]
[red-winged blackbird]
Pointed
[swallows]
Rounded [broad]
[red-tailed hawk]
Rounded [narrow]
[marsh hawk]
Pointed
[herring gull]
TAIL SHAPES
Rounded
(cooper's hawk)
Square
(sharp-shinned hawk)
Broad
(red-tailed hawk)
Narrow
(american kestrel)
Pointed or Wedged
(common grackle)
Notched
[tree swallow]
Forked
[barn swallow]

Figure 1-11. Typical wing and tail shapes

CFB-022

males are patterned like the female, although a trace of a reddish-orange wing patch often is evident.

Common grackle. There are two color phases (purple and bronzed) of this species of blackbird. The long wedge-shaped tail is the best field mark for this black-bodied bird with a purple, green, or bronze iridescence to its plumage. Females are less iridescent than males, and juvenile birds are a uniform dull brown.

Other blackbirds. Several other blackbird species often are found in blackbird flocks or roosts that present a pest situation. You should be able to identify the brown-headed cowbird, rusty blackbird, Brewer's blackbird, and yellow headed blackbird, if they occur near your base.

Exercises (25b):

1. On the following diagram, label each topographical feature of a bird.

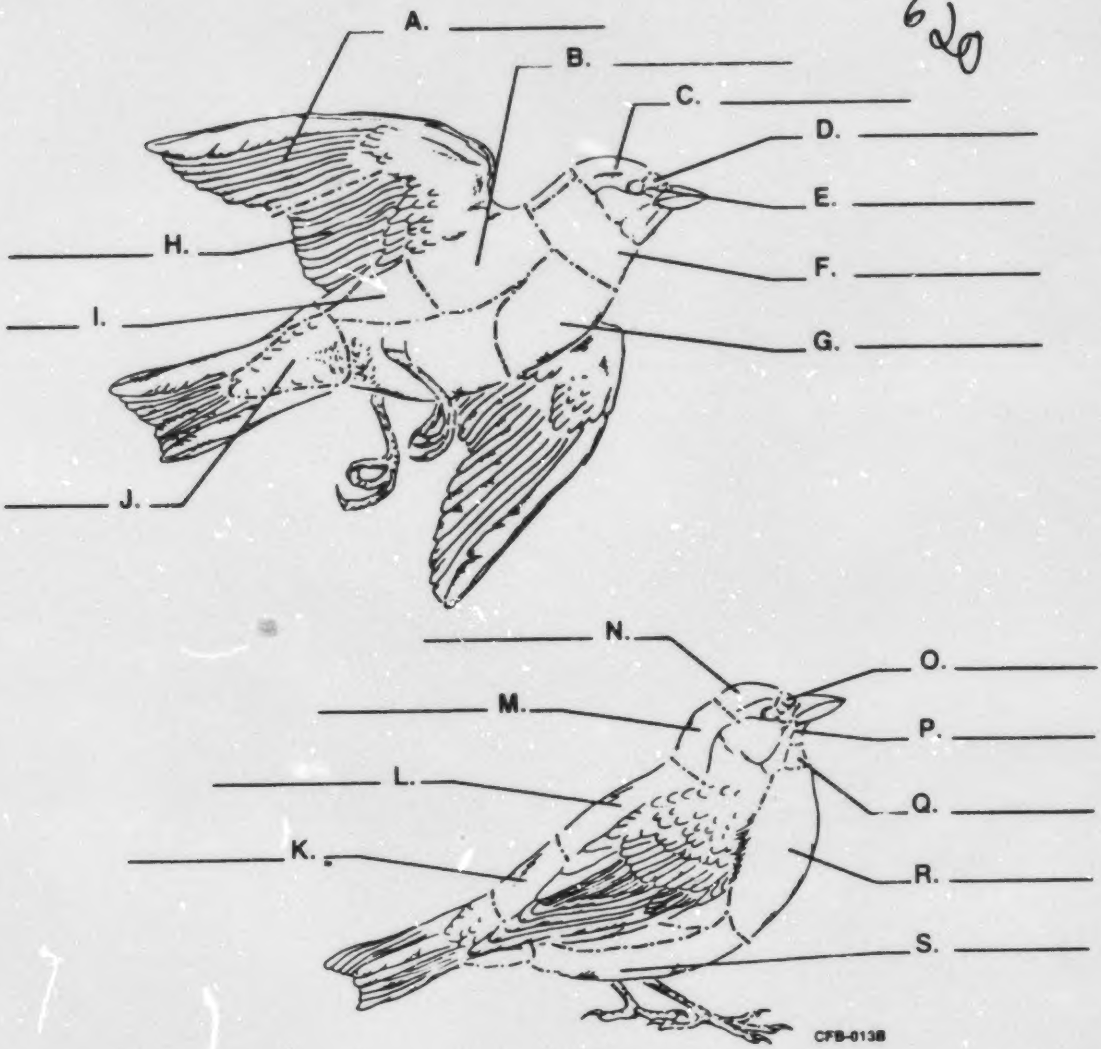

Figure 1-12. Objective C25b, exercise 1.

2. State the two feather groups that make up the flight feathers.

3. Explain what occurs when a bird spreads the large, conspicuous flight feathers of the tail.

4. What mode of feeding would be indicated by a hooked bill?

5. Match the bird in column B with the description in column A.

Column A	*Column B*
___ (1) Gray crown, black cheek and upper throat (adult male).	a. Common crackle.
___ (2) Long, wedge-shaped tail, black body, purple, green, or bronze iridescence to its plumage.	b. Gulls.
___ (3) Vary greatly in color and size; various color patters of gray, black, white, and bronze are common.	c. House sparrow.
___ (4) Pointed wings, square tail, and webbed feet.	d. Red-winged blackbird.
___ (5) Spring birds have a bright yellow bill and a green/purple iridescence.	e. Rock dove.
___ (6) Females are brown, heavily streaked, and spotted.	f. Starlings.

C25c (C39 -- for CF feedback reference only.) Associate bird-borne diseases with statements regarding their characteristics; complete given statements identifying economic, hazardous, and other aspects of bird problems.

Health hazards. Birds are associated with several diseases. They can transmit disease to humans and animals by becoming a reservoir for disease organisms, by transmitting organisms into the air or through their droppings, or by serving as intermediate hosts for disease organisms. Among the better known diseases are histoplasmosis, psittacosis, and encephalitis, although nearly 100 diseases are alleged to have been transmitted to man by birds.

Histoplasmosis. Histoplasmosis is caused by a fungus, *Histoplasma capsulatum*. The disease is worldwide in distribution, but it is more common in certain geographical areas such as the Mississippi River Valley region and other river valleys in the eastern and southeastern United States. The disease is contracted by inhaling the organisms which is present in soils. It thrives in soils enriched by bird droppings. Histoplasmosis usually results in benign lesions of the lungs caused by an infection which often shows no symptoms. However, in advanced stages the disease can be fatal. You should be aware of the increased potential for the spread of histoplasmosis that exists in certain situations. When species such as domestic pigeons, starlings, and house sparrows roost near areas where people work, the potential for histoplasmosis increases. The histoplasmosis spores usually are spread when soils enriched by bird droppings are disturbed. For example, construction near active or unused bird roosts can expose workers to the disease. You should give special attention to these situations and include control measures in any pest management program.

Psittacosis. Psittacosis, often called ornithosis or parrot fever, is caused by a rickettsia organism called a bedsonia. The name "ornithosis" was applied after the disease was found in many wild nonpsittacine (nonparrot) birds. This disease is distributed throughout the world wherever birds are found. Inhaling dust containing infective particles from bird droppings, feathers, bird bodies, and nasal secretions is a common source of human infection. During recent years, researchers have found that birds, such as pigeons, often transmit the disease. Pigeons have been responsible for a number of outbreaks of the disease in New York, Massachusetts, Minnesota, and California. The disease often has been traced to pigeons that nest or roost on or in buildings where people work. Wild birds also can spread the organism to commercially raised chickens, ducks, and turkeys, which die quickly after showing only brief signs of illness.

Encephalitis. Encephalitis is one of the more serious diseases associated with birds. A number of encephalitis viruses are carried by birds (the primary hosts) and can be transmitted to people and horses by arthropod vectors, mainly mosquitoes and ticks. The viruses for Western equine encephalitis, Eastern equine encephalitis, St. Louis equine encephalitis, and several other encephalitides have been isolated in birds. These viruses attack the central nervous system, and the mortality rate during outbreaks often is high. Birds host a variety of other diseases that can be transmitted to man. Human infection usually is caused by the transmittal of the disease organism by an arthropod vector or through inhalation or ingestion of contaminated air, water, or food. The potential for such diseases is highest where large numbers of birds congregate, roost, or nest.

Personal hygiene. You must guard against personal infection, particularly when handling birds or working in areas where birds have congregated. Gloves must always be worn whenever handling live or dead birds. When working in roosting areas, enclosed areas, or any area where bird droppings are prevalent, you should wear rubber boots and glove. To prevent infection by inhalation in such areas, a protective mask must be worn; disposable masks are recommended. Immediately after the operation, you must shower and wash your clothes and all equipment in hot water with a strong soap.

Sanitary disposal of birds. If you must handle dead birds, strict precautions are needed to preclude the spread of infectious materials. Gloves always must be worn. The feathers of any dead birds should be wetted thoroughly with a detergent disinfectant prior to handling. This step will immobilize lice and mites and help prevent the spread of airborne infective particles. Such specimens must be placed inside plastic bags or other such containers before transport to any other area. Dispose of specimens by incineration.

Bird strike losses. Each year the dollar loss from bird/aircraft collisions runs into the millions of dollars. The seriousness of the problem is indicated further by the loss of lives and the destruction of aircraft as a result of collisions with birds. A considerable portion of the aircraft loss and damage is caused by birds striking aircraft windscreens or canopies. Such impacts account for more than half of the aircraft that are destroyed by bird strikes and approximately 40 percent of all accidents. You should note that about half of all bird strikes, and 42 percent of the bird collisions with aircraft windscreens and canopies, occur during takeoff and landing. Appropriate bird control in the airdrome environment can significantly reduce these incidents. You must realize that damage to aircraft is not caused only by large birds. While collisions with birds such as swans, hawks, and vultures have caused damage and loss of aircraft, collisions, and engine ingestions of much smaller birds, such as starlings and swallows, have resulted also in damage and loss of aircraft and lives.

Other damage due to birds. While bird strikes account for most of the dollar losses caused by birds, other situations also cause concern. Bird droppings and nesting materials can damage equipment and supplies, particularly around hangers, warehouses, and other buildings. Birds also can damage agricultural crops, trees, and ornamental shrubs. Even small groups of birds can damage shade trees by eating buds during spring.

Inside aircraft hangars, birds enter engine housings and can accumulate a considerable volume of nesting material within a matter of hours. Engines, idle for repair, are prime targets. Nesting material can cause jet engines to fail by clogging intakes, and static and rotating blades can be significantly damaged by nesting material. Such problems usually are associated with house sparrows and starlings that enter hangars. Birds that nest in buildings or on equipment also present fire hazards if their nests are built around or near electrical wiring and switch boxes. Even if nests are not in a situation to cause fires, electrical failures can arise from birds shorting electrical systems or as a result of the corrosive effects of bird droppings on wires or wire insulation. Bird droppings within buildings are not only unpleasant but can result in substantial economic loss. Bird droppings corrode many metals and can cause serious damage if allowed to fall into dismantled engines or if allowed to build up on other equipment. In warehouses and other storage buildings, bird droppings on supplies often render them unusable or result in costly cleanup.

You must consider routine control of pest species, particularly pigeons, starlings and house sparrows as necessary to reduce hazards and prevent damage. These species should be eliminated to the greatest extent possible in the airdrome environment.

Exercises (C25c):

1. Match the diseases in column B with the appropriate statement in Column A

Column A	*Column B*
____ (1) Distribution is very common in river valleys of the southeastern part of the U.S.	a. Histoplasmosis.
____ (2) Attacks the central nervous system and has a high mortality rate.	b. Psittacosis.
____ (3) Has been traced to pigeons that occupy or roost on buildings.	c. Encephalitis.
____ (4) Birds are the primary host of this arthropod-borne disease.	
____ (5) This is a fungal disease.	
____ (6) This is found primarily in soil enriched by bird droppings.	

2. What disease is caused by a rickettsia organism called Bedsonia?

3. What must be worn to protect you against infection by inhalation when working in areas where bird droppings are prevalent and what type is recommended?

4. What is the proper disposal method of dead bird specimens?

5. In addition to the high dollar loss, what two other factors are even more serious as a result of bird aircraft collisions?

6. Around hangars, what are considered prime targets for birds to build nests?

7. What two bird species normally are associated with aircraft hangars?

C25d (C40 — for CE feedback reference only.) Match the control categories of bird management functions and cite basic facts regarding bird control.

Damage and hazard controls techniques fall into five general categories. For each specific bird problem, you should think through these five categories in turn, with an awareness of the variety of techniques available in each category. Each successive approach should be rejected only if no acceptable technique that is likely to be successful exists within that approach for the specific problem at hand. Table 1-2 is a guide to the active management techniques that apply to some common damage and hazard situations.

Altering the Concept. Altering the concept involves making a complete assessment of the situation at hand and deciding whether active management is required. The birds may merely be a nuisance or a transient problem caused by migration, with no active management program required. The cost of a management program also might exceed those of the damage being caused. Suspected bird damage situations should always be evaluated carefully. If no problem is verified, no control actions are required. "No action" is appropriate if close examination reveals that no economic damage, health hazard, or safety hazard exists. For example, someone may report large numbers of birds at a certain locality. If an investigation determines that the presence of birds does not conflict with mission activities, no control action is required. All birds around buildings are not pests necessarily. Furthermore, birds that are considered pests by some people may be considered desirable by others.

Altering the Situation. Altering the situation involves changing the timing or procedure of mission operations to avoid conflicts with birds. Also, included in this category is habitat modification. This includes elimination or reduction of bird habitat (food, water, roost or nest sites, and perches) near the airfield and is the most permanent solution to many pest bird problems. Changing mission activities consists of modifying procedures to avoid or reduce a potential conflict between birds and aircraft. Changing mission activities applies to many types of situations, particularly those of a temporary nature; for example, the presence of migratory birds. After evaluating the circumstances of a potential hazard in a particular situation, one can select the type of changes in mission activities that may solve a particular problem. Two or more specific recommendations may be combined, depending on the severity of the problem at hand. You should identify the

TABLE 1-2
GUIDE TO ACTIVE* BIRD MANAGEMENT TECHNIQUES

Species	Situation	Potential Control Measures (in the order to be considered)
Pigeons	Around buildings	Design and construction Screening or netting Sharp projections Sticky repellents Water hoses Avitrol Pigeon trap Shooting
House Sparrows	Around buildings	Design and construction Screening and netting Sharp projections Sticky repellents Water hoses Avitrol Modified Australian crow trap Commercial live trap Nest-box trap
Starlings	Roosting in or on buildings	Design and construction Screening or netting Sharp projections Sticky repellents Distress/alarm calls Electronically produced noises Bird bombs
Starlings	Nesting around buildings	Design and construction Screening or netting Sharp projections Sticky repellents Nest-box trap
Gulls	Feeding on or near airfield	Elimination of food source Distress/alarm calls Electronically produced noises Airbursts or scare cartridges, bird bombs Automatic exploders
Other water birds	Creating strike hazard near airfield	Elimination of water source Elimination of food source Netting or wire Airbursts, scare cartridges, bird bombs Automatic exploders Rope firecrackers Shooting (waterfowl hunting)
Birds of prey	Creating strike hazard near airfield	Elimination of food source Elimination of nesting, roosting, or perching sites Sharp projections Sticky repellents Raptor traps
Other land birds	Creating strike hazard near airfield	Elimination of food source Elimination of nesting, roosting, or perching sites
Starlings	Feeding situations	Elimination of food source Distress/alarm calls Electronically produced noises Airbursts, scare cartridges, bird bombs Automatic exploders Rope firecrackers Avitrol Modified Australian crow trap Commercial live traps Starlicide
Blackbirds and/or Starlings	Roosting in trees	Elimination of roosting sites Distress/alarm calls Electronically produced noises Airbursts, scare cartridges, bird bombs Automatic exploders Sticky repellents Wetting agents
Gulls	Loafing on airfields	Elimination of roosting sites Elimination of food sources Elimination of water sources Distress/alarm calls Electronically produced noises Airbursts or scare cartridges, bird bombs Automatic exploders

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* Altering the concept and using advoidance measures, which are not listed, should be considered (if applicable) prior to an active bird management program.

circumstances of the conflicts between birds and flight operations with the base flight safety officer. He can recommend changes in operational procedures to the appropriate organization. Providing pilots with information on birds is one way to alter the situation by changing mission activities. Pilots can be alerted to hazardous bird areas by posting information in Base Operations and by tower/pilot communication. Pilots can be informed of the numbers, location, and altitude of birds in the same manner they are informed of severe weather conditions. Changes in operational procedures have been recommended in certain instances by the Bird/Aircraft Strike Hazard (BASH) Team of the Air Force Engineering and Services Center. These include restricting the use of certain runways, allowing only full-stop landings, avoiding long final approaches, reducing approach and climb-out speeds, restricting formation rejoins on departure, and raising radar vectoring altitudes. A base Bird Hazard Working Group (BHWG) is made up of members from Flying Safety, Director of Operations, Flight Facilities, Base Operations and Civil Engineering. Ideally it is a subcommittee of an existing group such as the Air Traffic Control Board, Safety Council or a similar group. The group should review the local flying operation and determine modifications needed to reduce bird hazards and make pilots more aware of the hazards. The BHWG and the PM should work together on the following:

Elimination of food sources. If birds are attracted by a food source, removal of the food source will result in fewer birds in the area. Various techniques are used, depending on the situation. In many cases food is the major attraction for birds. Some typical examples and potential methods of eliminating these sources of food are as follows:

a. Exposed garbage at landfills attracts scavengers such as gulls, crows, and starlings. If a landfill is properly operated, with refuse being continuously covered with soil, large numbers of birds should not be attracted. You can encourage proper landfill operations. If necessary, landfills causing serious bird strike hazards should be closed, and the refuse covered permanently. Garbage around buildings should be eliminated or kept in covered containers to preclude attracting pest birds such as starlings and pigeons.

Weed seeds in grassy areas attract many birds, such as mourning doves and horned larks. The amount of weed seeds produced can be reduced by mowing operations or by regular application of herbicides. For areas that cannot be mowed, controlled burning is an alternative. Safe burning requires predictable weather conditions and considerable skill and should be performed only by experienced personnel.

Insects in grassy areas attract many types of birds including cattle egrets and meadow larks. Proper timing of mowing operations to avoid exposure of insects at times of heavy runway use may keep insect populations in check without creating a strike hazard. If necessary, insects can be controlled by spraying.

b. Earthworms attract birds such as American robins to short-grass areas. Following a rain, scavengers such as gulls may be attracted to runways to feed on earthworms. Runways can be swept clean of earthworms with runway sweepers.

c. Rodent populations in grassy areas may attract raptors (hawks and owls). Keeping the grass mowed short will eliminate the rodent habitat and, in turn, reduce the food source that attracts the raptors. A grass height of 8-12 inches is recommended to discourage birds that prefer shorter grass for roosting without attracting large numbers of rodents and birds that prefer taller grass.

d. Carrion-eating birds (such as vultures, crows, and gulls) may be attracted by dead animals on the airfield. This food source can be reduced by frequent inspections, removal, and proper disposal of the carcasses.

e. Fruit, such as berries, produced by trees, shrubs, and vines, including ornamental plantings, may attract birds such as swallows, warblers, or starlings. This food source can be eliminated entirely by removing the fruit-bearing vegetation. With ornamental plantings, it may be preferable to exclude the birds by netting during the fruiting time. Growth inhibitors can be used before fruiting to reduce food supply.

f. Agricultural land near an airfield can create a bird/aircraft strike hazard by attracting large numbers of birds to a food source. For example, flocks of blackbirds may be attracted by grain crops or by waste grain following harvest. Another type of hazardous situation may be created when plowing or mowing exposes worms, grubs, and flying insects which attract birds. Such problems may be beyond the immediate control of the PM. If the land is Government-owned, the problem may be solved by not leasing for agricultural purposes or by stipulating in the lease agreement that grain crops not be grown. Local farmers can be encouraged to plow the fields after harvest to reduce the attractiveness of waste grain to birds.

Elimination of water sources. If birds are attracted by a source of water, removal of the source will result in fewer birds in the area. Depending on the particular situation, various techniques are used, some of which are as follows:

a. Low areas or clogged drainage ditches may collect water, attracting waterfowl, gulls, or smaller shore birds. Elimination of such temporary water sources will reduce the attractiveness of the area to birds considered to be potential strike hazards. If permanent ponds create a strike hazard, draining and filling may be necessary. Low areas that collect water can be eliminated by installing covered tile drains or by filling and regrading. Drainage ditches can be replaced by buried drainpipe. All ditches, drains, and culverts should be unclogged. Open drainage ditches should be cleared at regular intervals.

b. Elimination of water sources solves the problem at its origin and is a permanent solution, except that periodic maintenance of drainage systems is required. Breeding areas for insects are also eliminated by removing sources of water. However, major filling operations or installation of drainage pipes and culverts is costly. Draining and filling permanent ponds is impractical, unless a very serious bird strike potential exists.

c. Ponds, streams, marshes, and swamps often are strictly regulated by law. Appropriate local and state permits may be required before such sources of water can be altered or eliminated.

Elimination of nesting, roosting, and perching sites. If birds are attracted by the vegetation cover (or the openness) of an area, a reduction in the cover (or openness) provided will reduce the number of birds attracted by this type of habitat. In some circumstances, removal of favored perching sites also will discourage birds from frequenting an area. Some of the techniques employed in this area are listed as follows:

a. Crows, starlings, and blackbirds that roost in trees often can be discouraged from using the roosting site by topping or thinning (pruning) the trees. Birds roosting in tall reeds (blackbirds or swallows) can be discouraged by cutting the reeds to a shorter height. Birds (meadowlarks) that roost or nest in tall grass can be discouraged from an area by mowing the grass short. For areas that cannot be mowed, controlled burning is an alternative. If gulls load in open areas of short grass, they can be discouraged by allowing the grass to grow to a height which will obstruct their vision and make it difficult for them to spread their wings freely. Removal of dead snags on which hawks frequently perch may discourage these birds from frequenting the area.

b. Intensive pruning discourages birds from roosting in trees. A sparse tree canopy provides few perching sites and little protection. More branches should be removed than normally would be removed in residential pruning. In instances where birds roost in tall trees, topping the trees to a height of 20-30 feet may be effective. A more drastic measure would be the complete or nearly complete removal of the trees.

c. Grass height in open areas can be controlled by mowing to eliminate nesting or roosting habitat. To compromise between short grass that is attractive to gulls and long grass that attracts other birds, maintenance at a height of 8-12 inches is recommended. If mowing operations expose insects that attract birds, it may be preferable to mow at times when runways are not being used heavily by aircraft, such as at night or on weekends.

d. You must recognize that the removal or thinning of roost may result only in the birds moving to nearby sites. Careful maintenance of grass is required. Short grass in open areas may attract gulls for loafing. Mowing grass too short can replace one pest situation with another, perhaps creating a more serious problem. Allowing it to grow too long may result in an increase in other birds as well as small mammals that attract raptors. Tall grass sometimes is considered unsightly. Mowing operations may attract birds temporarily by exposing insects. As with other methods of habitat manipulation, some of these control procedures can be costly in terms of manpower required. Also, habitat modification techniques that may result in the disturbance or harassment of protected species will require appropriate permits. For example, active raptor nests are protected by Federal law. Therefore, trees containing such nests cannot be cut down without a permit. The use of controlled burning also requires appropriate permits.

Exclusion. Exclusion means preventing birds from gaining physical access to an area where they can create a problem, such as roosting or nesting in buildings. Some exclusion techniques actually are habitat modification. It is most effective when considered during design and construction of new structures, but techniques are available to exclude birds from existing structures. The design of structures frequently is responsible for their attractiveness to domestic pigeons, starlings, and house sparrows. Design modifications or additional construction to eliminate roosting and nesting locations can provide effective bird control. Unfortunately, you may not have an opportunity to comment on structure design during the planning stages. However, additional construction may be feasible to modify features of structures that attract roosting or nesting birds. For example, open eaves of a building may be boxed to prevent access. Flaws in building construction causing cracks or crevices that attract starlings or house sparrows can be sealed with boards, bricks, or mortar.

The building materials needed will depend on the particular design modifications required. Boards, bricks, motar, or sheet metal are frequently appropriate. Screening should be considered as an alternative. Cavities being used by birds can be located by looking for accumulations of bird droppings, protruding nest materials, or by careful observation of birds. Birds may be reluctant to enter a nesting cavity if an observer is nearby, so the PM should use field glasses and watch from a distance. When the problem areas have been identified, select the appropriate building material, remove existing nests, and seal off the opening.

Eliminate ledges used as perching locations by installing angled board, a piece of sheet metal, or a row of bricks. Design modification is a permanent method of pest bird exclusion. Unless conducted during actual nesting, it is not likely to cause an adverse public reaction and is thus a socially acceptable means of preventing protected species, such as robins or swallows, from nesting on structures in the future.

Screens, nets, or wires. Exclusion by means of screens, nets, or wires consists of installing materials that will prevent the physical access of birds to areas where they roost, nest, or feed.

a. Screening or netting frequently is used to prevent pigeons, starlings, or house sparrows from roosting or nesting in or on buildings or other structures. Ventilation holes can be screened to exclude starlings and house sparrows. Chimneys can be covered with screening. Netting or crisscrossed wire has been used to exclude birds from drainage ditches or other water areas that attract water fowl, gulls, or other birds. Screening can be used to exclude birds such as starlings and gulls from filter beds and settling tanks of sewage treatment facilities.

b. Piegons and starlings sometimes can be discouraged from hangers or warehouses by suspending netting from the top of the large doorways. The birds may be reluctant to fly low enough to enter under the netting. This technique is not effective against house sparrows, nor has it been scientifically tested, so the maximum ground clearance that will be effective and the probability of success are unknown. Netting also is used in agricultural situations to prevent bird depredation of fruit crops. Similarly, netting can be used to prevent the attraction of birds to certain vines, shrubs, or trees that have been planted for ornamental or gardening purposes.

To exclude birds from relatively small areas, 1/2-inch mesh screening is recommended. To enclose larger areas, such as an aircraft hangar superstructure, or to partially screen large doorways, nylon, or polyethylene netting can be used. Several materials can be used to cover fruit trees or vines, including acrylic fiber webbing and plastic netting.

To control pigeons starling, and house sparrows in aircraft hangars, you should clean the hangar with high-pressure water. Deicing booms may be used to wash down girders and remove nests. Ensure that all electrical power to the building is turned off to eliminate the shock hazard. Scrape beams where droppings have accumulated before washing, then spray with disinfectant where nests are removed. Wash hangar floors and treat with disinfectant. Dispose of all removed nests and all dead birds by incineration. Replace insulation. Ensure that the screening does not touch the insulation to prevent birds from pulling insulation fibers through the mesh. Screen off all nesting and resting areas, such as edges of runs, ducts, and conduit races, spaces between the wall and utility runs, and around heating units. Suspend netting as required to enclose larger areas.

The technique of crisscrossing wire across water bodies requires the use of heavy gauge wire (at least 10 gauge) to minimize the potential for injury to birds. Nylon monofilament lines of 50- to 100-pound test can be substituted for wire. Posts should be placed about 6 feet apart on each side of the body of water, alternating the position of the posts with those on the opposite site. Wire is then strung in a zigzag manner across the water at approximately 12 to 18 inches above the waterline. This technique is effective against large birds only. If properly installed, screening or netting is a permanent solution to a pest bird problem, although periodic inspection and maintenance are required. Exclusion of birds is socially acceptable and should not cause a public relations problem. Netting and screening are appropriate means of excluding protected species.

Sharp projections. Sharp projections, wires, or spikes can be used as barriers and repellents to perching birds on buildings and other structures. These devices can effectively prevent any bird from perching on ledges or other surfaces. A sample application is shown in figure 1-13. They are installed most commonly to discourage

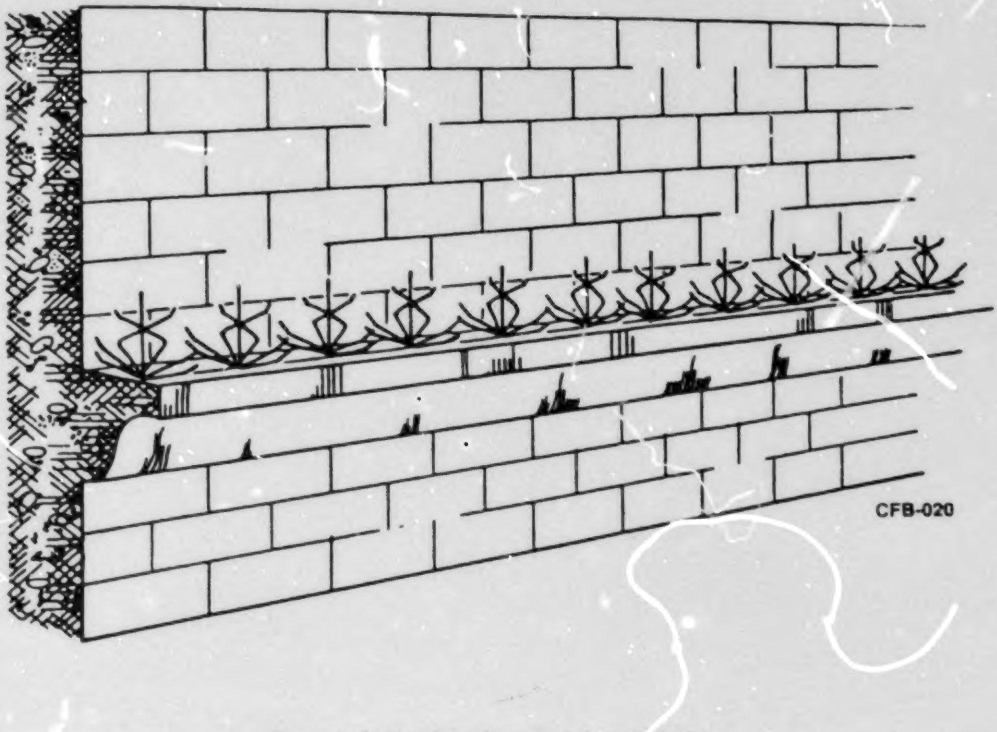


Figure 1-13. Sample application of sharp projections

pigeons, starlings, and house sparrows from structures. Sharp spikes also have been used successfully to prevent raptors from perching on runway marker lights. These devices are available in strip form and are placed with clips, fasteners, wire ties, and adhesive, as appropriate for particular installation requirements. Different designs of projection material are available for large birds, such as gulls or pigeons; and for smaller birds, such as starlings or house sparrows. This material can be installed on ledges, rafters, window sills, or other locations where birds might roost, loaf, or nest. Wide surfaces may require two or more parallel rows of the material. Detailed instruction on the appropriate type of adhesive or fastener, as well as recommended spacing, will be provided when the material is procured. Determine the appropriate locations for this material by observing birds directly or by noting heavy concentrations of droppings. Sharp projections are an effective and permanent means of excluding or repelling birds from ledges, rafters, and other structures. Because of the sharp spikes (projections), these devices should not be used in accessible areas where a safety hazard might result.

Repulsion. Repulsion is simply scaring birds away. Many devices and techniques have been designed to repel birds. Techniques used for birds on airfields usually are visual (sight), tactile (touch), and auditory (hearing). For our purpose here we will concentrate on the auditory repulsion technique. When using auditory repulsion (the type most commonly used to prevent strike hazards), the keys to success are diversity and intensity. We will discuss the four types of repulsion techniques:

Recorded distress/alarm calls. This bioacoustic technique consists of using a loudspeaker and cassette tape player to broadcast a recording of actual distress or alarm calls of the same bird species to frighten away flocks of birds.

Distress or alarm calls are recommended highly for dispersing flocks of gulls from an airfield. In the Air Force, this is their primary use. This technique also is frequently effective in dispersing blackbirds or starlings from roosts in trees or starlings roosting in hangars. Distress or alarm calls also can be used in many other situations, if tapes are available for the species that is causing the pest situation. Repulsion techniques are most effective with transient birds and are more effective with roosting or loafing birds than with those that are nesting. Auditory repulsion is not recommended for pigeons or house sparrows.

b. Equipment consists of a vehicle from which to broadcast the calls, sound equipment (tape player with amplifier and loudspeaker), and the appropriate cassette tape recordings for the pest species. The loudspeaker can be mounted on the vehicle. The sound equipment must play the tapes loudly and with good fidelity. A system capable of 30-50 watts power without distortion to produce 90-110 db (several feet in front of the speaker) and a frequency response of up to at least 20,000 Hz is recommended. This equipment is covered in Table of Allowance 483. The system can be powered directly by the vehicle through the cigarette lighter, using an ac/dc transformer. Recorded tapes of distress/alarm calls for various species can be obtained from the Air Force Engineering and Services Center, Tyndall AFB, Florida. If available, alarm calls usually are preferable to distress calls, because some birds are dispersed more readily by alarm calls.

c. As with other repulsion techniques, it is best to start a control program before the birds establish the habit of using the area. If the birds already frequent the area, observe their usual movement pattern. It is easier to herd them along accustomed flight patterns than to disperse them at random.

Proper identification of the birds is even more important than with other repulsion techniques, because many birds respond only to distress or alarm calls of their own species. Even gulls should be identified as to species before a tape is selected. In mixed flocks, the disperal of one species will sometimes, but not always, disperse the other species.

For loafing gulls, drive the vehicle to within 100-200 yards of the birds. Note the wind direction because sound carries farther downwind. If birds are roosting in trees, it will be necessary to get even closer, because the trees will muffle the sound of the recording. In hangars, the sound may echo, making it unrecognizable to the birds. Try different locations within the hangar; it may be desirable to move the speaker up to ceiling level. At tree roosts and loafing areas, play the tape from different locations.

d. To keep birds from habituating to this control technique, play the tape as little as possible and never allow it to run continuously. Two or three attempts should be sufficient. If the birds do not fly up and disperse after the third attempt, it is unlikely that they will be influenced by the distress call. *Do not allow the tape to continue running,* because this will persuade the birds that they are not in danger, and they will ignore the tapes. Frequently the birds rise up and fly toward the loudspeaker when the distress call is used. Sometimes they circle for a short time over the source of the distress call and then fly away. At other times they may circle the vehicle and spiral higher and higher, creating a hazard to aircraft. Pyrotechnics should then be exploded among the birds to speed their departure.

For starlings or blackbirds at roosts, the technique should be applied when the birds are arriving at the roost. Play the tape 15-30 seconds at a time for a total of only a few minutes during this period. Apply the technique for four to seven successive nights. Recorded distress or alarm calls can be reinforced with airbursts of scare cartridges or live ammunition. This will help convince the birds that a danger is present, and they will be more likely to heed the recorded calls and disperse.

In many situations this is probably the most effective repulsion technique available. If the technique is applied properly, habituation is not as likely to occur as with other techniques. Except for the reinforcing [illegible] no other supplies are required. The birds are not harmed physically by the distress or alarm calls. This method entails no fire hazard, no [illegible] problems, and no chemical residues.

e. Circling gulls may [illegible] an immediate strike hazard until completely [illegible] [illegible] background noise levels will reduce the probability of success by impeding the birds' ability to hear the recording. Echoes and distortion of the calls when played inside a hangar or between buildings may reduce effectiveness. The recordings are disturbing to some people. As with any repulsion method, roosting birds that are moved may become a problem elsewhere. Repulsion alone will not permanently solve a problem; habitat changes also should be made. However, playing recorded distress/alarm calls is harassment and cannot be used on protected species without a permit. If live ammunition is used as reinforcement, depredation permits also are required for protected species, including gulls.

Electronically produced noises. Electronically produced noises which simulate bird calls can be broadcast by loudspeaker in the same manner as recorded distress/alarm calls to repel birds. Ultrahigh frequency sounds (ultrasonics), which cannot be heard by humans, are not recommended for bird control because their effectiveness is questionable.

a. Like recorded calls, electronically produced noises can repel flocking birds (blackbirds, starlings, gulls) from feeding and roosting situations with varying degrees of success. Auditory repulsion techniques are not recommended for piegons or house sparrows. Electronic noises can be used in enclosed areas such as hangars and in open and wooded areas.

b. Electronic bird repulsion systems are available from commercial sources. Several models are available; low power for enclosed or small areas and high power for larger, open areas. They can be played from a vehicle or permanently installed, but mobile units are more effective and can cover a larger area. If installed, several stationary speakers or a rotating (or partially rotating) speaker is recommended so that the direction of the broadcast can be varied. The systems can be operated manually or automatically. A timer can be used to turn the system on for a few seconds every several minutes. A photocell can activate or deactivate it at dawn and dusk. To increase effectiveness, the location of mobile units should be changed frequently. In a small area, high volumes are not necessary, as long as the birds can hear the sound. Because the noises can be very irritating to people, unnecessarily high-noise intensity should be avoided.

c. Like recorded calls, the effectiveness of this technique can be increased by using it in combination with other techniques such as airbursts or automatic exploders. Birds may exhibit a delayed response, perhaps being attracted at first or acting curious toward the noise before taking flight. Repulsion programs should begin before a pattern has been established for the season, and the sounds should be played as birds arrive at a feeding or roosting area. Persistence often is required. Many variations of noises can be produced by the same equipment. Tapes of calls for various species are not required. Different combinations of noises may repel more than one species at the same time. Experimentation with different noises is possible.

d. Many electronically produced noises will be ineffective unless some biologically meaningful message (such as alarm) is conveyed to the birds. For this reason, the use of actual recordings of distress/alarm calls, if available, is preferable to electronic simulations. The noises produced can be very irritating to people. The base bioenvironmental engineer should be asked to assess the noise hazard potential and to make recommendations.

M-74 airbursts and scare cartridges. M-74 (M-74A1) airbursts are explosive charges fired from an M-1 pyrotechnic pistol (flare gun). Scare cartridges are 12-gauge shotgun shells that propel a second charge instead of pellets. The propelling charge of airbursts and scare cartridges ignites the fuse on the second charge and projects the charge about 100 yards, where it explodes with a loud noise and a flash of light.

a. Airburst and scare cartridges are fired into the air to repel flocks of birds such as blackbirds, starlings, crows, gulls, or water fowl. These pyrotechnics can be used in conjunction with distress/alarm calls to repel birds coming in to roost (blackbirds and starlings) or to discourage gulls from loafing in the vicinity of runways. These techniques seldom are effective for pigeons or house sparrows.

b. Procedures for ordering M-74 airbursts may be obtained from the Munitions Supply Office, Security Police Squadron (supply account code FK) on each base. Also, Technical Order 11A-1-46, *Fire Fighting Guidance, Transportation and Storage Management Data and Ammunition Complete Round Chart,* contains information on shipping, storing, and handling the airburst. An M-1 pyrotechnic pistol is required to fire the airburst. Scare cartridges are available from commercial sources. Scare cartridges can be fired only from 12-gauge shotguns with no choke or an open choke barrel. A choke-bore shotgun will slow the projectile, possibly resulting in explosions inside the barrel. The following instructions apply to the M74A1 simulator airburst and the 12-gauge scare cartridge.

(1) Pyrotechnics must be fired at an angle of not less than 45° from ground level and never in the direction of any person, vehicle, or building closer than 1000 feet.

(2) All firearms safety rules listed on AF Form 497, Air Force Policy Statement-Firearms Safety and Use of Force, will be followed.

(3) Leather gloves, ear protectors, and goggles must be worn by the user. All other personnel in the area should have ear protectors.

(4) There should be no smoking at any time within 50 feet of pyrotechnics.

(5) If pyrotechnics malfunction, all personnel will stay clear of that area for at least 30 minutes. The exact position of the malfunction will be relayed to the base explosive ordnance disposal (EOD) office. They will send a team to the area for disposal. At no time will pest management personnel dispose of any malfunctioned pyrotechnics.

(6) Except during transportation, pyrotechnics will be kept under visual observation at all times after they are issued and until they are expended.

(7) Two-way radios must be used to coordinate with

the control tower before pyrotechnics are fired.

(8) When transporting M74A1 airbursts, four "Explosives B" placards must be placed on the vehicle, one on each side. These placards are available from the Department of Transportation. Refer to Standard Form 432. The 12-gauge cartridges currently do not have a permanent explosives classification.

(9) Pyrotechnics should be stored in a metal box lined with wood on all inner surfaces and secured in the vehicle during transportation.

(10) Before using pyrotechnics, the following offices should be notified: Command Post, Hospital, Security Police, Fire Department, Ground Safety, and Explosives Safety.

The following procedures must be followed when using pyrotechnics:

(1) Proceed to the area where the birds are a hazard.

(2) Obtain Control Tower clearance to fire pyrotechnics.

(3) Don all applicable safety equipment.

(4) Remove pyrotechnics from the storage box and load the weapon.

(5) Grip the weapon with both hands, aim high towards the target, and fire.

(6) Inspect the weapon chamber and barrel before reloading to be sure it is free of obstructions.

(7) Dispose of empty casings properly. If discarded on the airfield, they may be picked up by birds and dropped on the runway, where they can be ingested by an engine. For the same reason, unexploded projectiles must be recovered. When unexploded projectiles occur, EOD personnel must be contacted to dispose of the explosives.

(8) After bird dispersal, return the pyrotechnics to the storage box and then to the appropriate office.

(9) To protect against fires, two 10-pound extinguishers for type B and C fires always must be available when using pyrotechnics. In the event of a fire on the airfield, pest management personnel should immediately stop using pyrotechnics, attempt to extinguish the fire, and notify the control tower to relay information to the fire department.

c. When pyrotechnic devices are used without other repulsion techniques, birds may habituate to the noise, reducing the effect. This tendency can be reduced by occasionally using live ammunition with the pyrotechnics to show the birds that a hazard is present. Pyrotechnic devices are used most effectively in conjunction with recorded distress or alarm calls. This reduces the potential for habituation to either technique.

The keys to success are diversity and intensity. Fire the airbursts or scare cartridges at irregular intervals and combine their use with other repulsion techniques. When attempting to disperse a roost, provide daily harassment (as the birds arrive) for a period of 3 to 7 days. It is easier to turn birds back when they are approaching a roost than to scare them out of a roosting area after they have settled. Airbursts or scare cartridges are often an effective method of repulsion, at least for a short time, and increase in effectiveness when used in conjunction with other techniques.

Automatic exploders. Automatic exploders, sometimes called gas cannons, produce loud noises (similar to those of a 12-gauge shotgun at regular intervals).

a. Automatic exploders can be used in conjunction with other control methods to frighten birds away from airfields or hangars. They are mainly for open situations. These exploders are reported to be particularly effective for waterfowl but also have been used (with varying degrees of success) for gulls, blackbirds, starlings, crows, and other birds in both feeding and roosting situations. They should be most effective on those species that are regularly hunted and thus are likely to associate the noise with gunfire. Auditory repulsion techniques generally are not effective for pigeons or house sparrows.

b. Exploders should be used in combination with other control techniques. Airbursts will help keep the birds from becoming accustomed to the noise of the exploders. Where birds are attracted strongly to an area, explosions at 1- to 2-minute intervals can be tested for effectiveness. One cannon can repel birds from an area of approximately 10 acres. Several exploders usually will be required in most airdrome situations. The effectiveness is increased if the cannons are pointed downwind. The location should be changed frequently, perhaps every hour, but at least daily. If this is not done, the birds will soon ignore the noise. For ease of movement, the exploders can be mounted on a vehicle. While in operation, the mechanism should be checked periodically. Repulsion should begin when birds begin feeding or roosting in an area. This is more likely to be successful than starting a program after a pattern has become established for the season. It is even better if the program can be started before the birds' estimated arrival time, based on experience from previous years.

c. A propane operated scareaway gun for bird dispersal is listed in Table of Allowances 483. This model operates from liquid propane, which is ignited by a flint that sparks when struck by the firing mechanism. The timing of explosions is determined by gas pressure. This technique is not harmful to birds. Gas cannons have a low-operating cost compared to shotguns or airbursts.

Removal or Reduction by Capture. These techniques attempt direct population control by capture or killing. As a general rule, this approach is rarely effective. Even if a large proportion of the flock is removed (a difficult task), other birds eventually will move in to replace them if the original environmental attraction remains. Killing birds also is likely to result in adverse public reaction. Nevertheless, there are instances when habitat modification, exclusion, or repulsion are not viable approaches, and direct population reduction is appropriate. In this area we are talking about trapping birds unharmed. We will discuss six types of bird traps.

Commercial live traps. Traps designed to capture birds unharmed are available in a variety of designs from commercial sources. Birds are attracted by bait, perhaps in combination with live decoys. Captured birds can be killed by gassing or, preferably, transported for release elsewhere.

a. Commercial live traps can be used to capture domestic pigeons, starlings, or house sparrows. Trapping is not practical over large areas or where large populations are present, but considerable numbers of pest birds can be removed from limited areas with persistent effort. If birds are not feeding, they may be encouraged by prebaiting. Birds are more easily attracted to bait in winter because natural food is less available. Starlings, however, do not usually feed near their roosts.

b. Traps of many designs are available from commercial sources or could be manufactured within your organization, if resources are available. Each trap is designed to capture a particular species. The designs include swinging-bob pigeon traps, funnel traps for pigeons, center-drop traps for starlings and house sparrows, funnel traps for house sparrows, and some novel designs. Many models capture dozens of birds at once, and some have multiple chambers to increase their capacity and prevent escape. Traps should be placed where they will not be disturbed. They should be baited (inside and around the trap) with a food preferred by the species sought and provided with an ample water supply. Pigeons can be attracted by whole corn, house sparrows by finely cracked corn, and starlings by cracked corn, peanut butter, or apples. Traps must be checked daily. Several calm, healthy birds left in the trap to serve as decoys will often increase efficiency. Protected species should be handled carefully and immediately released. Nonprotected birds causing a pest problem should be released at least 40 miles away. The trap can be covered with a tarpaulin (after removal of protected species and decoys), and the birds killed by gas through a hose connected to the exhaust pipe of a vehicle. Dead birds must be incinerated.

c. Live-trapping and release is a socially acceptable means of removing birds. Even if pest birds are killed by gassing, live-trapping is less likely to cause a public relations problem than poisoning. Protected species usually can be released unharmed, although frantic birds may be injured in the trap. Live-trapping is expensive and time consuming, because it requires considerable persistence to be effective even on relatively small populations in limited areas. Removal is not a permanent solution to a pest problem, as other birds will move in to fill the available habitat. Therefore, eliminating the habitat is the preferred solution.

Pigeon traps. A piegon trap consists of a screened enclosure with an entrance through which birds are lured by bait and live decoys. The entrance door is made of lightweight rods that only swing inward, thus preventing the birds from leaving the enclosure.

a. Trapping reduces the numbers of pigeons feeding, roosting, or nesting around buildings. Pigeon traps can be constructed of wood or meshed wire, with entrance bobs made of aluminum or steel wire or wooden dowels. Figure 1-14 illustrates a low-profile trap. Preconstructed individual bobs or bobs in a frame can be obtained from commercial sources, as can completely assembled traps of various styles.

b. Place the traps near feeding or roosting locations, but where they will not be disturbed; a flat rooftop is often a good location. Observe the pigeons' feeding habits to determine suitable trapping locations; for example, if they are feeding in open fields, place the traps in a field. If the birds have been feeding near the runway, do not prebait and trap in this area. Instead try to lure the pigeons to an area away from the runway. Post signs advising people to remain clear of the trapping area. For bait, use preferred food such as cracked corn or other grain. Spread some bait around the door of the trap, and put an ample supply of bait and water inside. Tie the bobs open and prebait for 2 weeks to lure the pigeons to the food source and allow them to become accustomed to entering the traps. After the prebaiting period, untie the bobs to activate traps. During several weeks of operation, check the traps daily. At each check, remove captured birds to await transport and release, leave two or three healthy birds as decoys, and replenish food and water as necessary. If too many birds are left in the trap, all bait will be consumed and few other birds will be attracted. Try to leave the same individuals as decoys each time so that they will become tame. Leaving birds with distinctive color patterns will facilitate identification; bright-colored birds also seem to be more effective decoys than the duller blue-gray birds. A portable holding cage may be constructed for transporting the captured birds. Mark these birds with indigo red dye to allow recognition of birds returning to the area. Transport birds to an appropriate area at least 40 miles from the base and release. If any marked birds return to the traps or the affected building, dispose of them in a humanitarian manner as directed by the hospital commander. After several weeks of trapping, another prebaiting period is recommended, followed by several weeks of trapping. If trapping is unsuccessful, the birds must be destroyed.

c. Pigeons with leg bands or nontarget species such as mourning doves can be released unharmed. Trapping does not involve the hazards associated with toxic chemicals. Fairly large numbers of birds can be captured and removed during proper trapping programs. At best, trapping will remove only 75-80 percent of the resident pigeons in any area. Results are not rapid and considerable effort is required. Removal is not a permanent solution to the pest bird problem, because other birds will move in if the source of attraction remains. Pigeons are not federally protected, so there are no legal restrictions on the capture of pigeons by live-trapping in most localities. In some areas, however, all birds including pigeons are protected by local regulations. The PM should contact the base office of the Staff Judge Advocate to determine permit requirements.

Modified Australian crow trap. This type of trap also is known as the center-drop trap. The modified Australian crow trap captures birds unharmed by luring them with bait and live decoys. The principle is that bird drops through an opening at the bottom on the V-shaped top of the trap to take the bait as shown in figure 1-15. When attempting to leave, they go up into the ends of the "V" instead of back through the entrance slots.

a. This trap is an effective means of capturing starlings, house sparrows, blackbirds, and other problem birds in an area of limited size. The design illustrated in

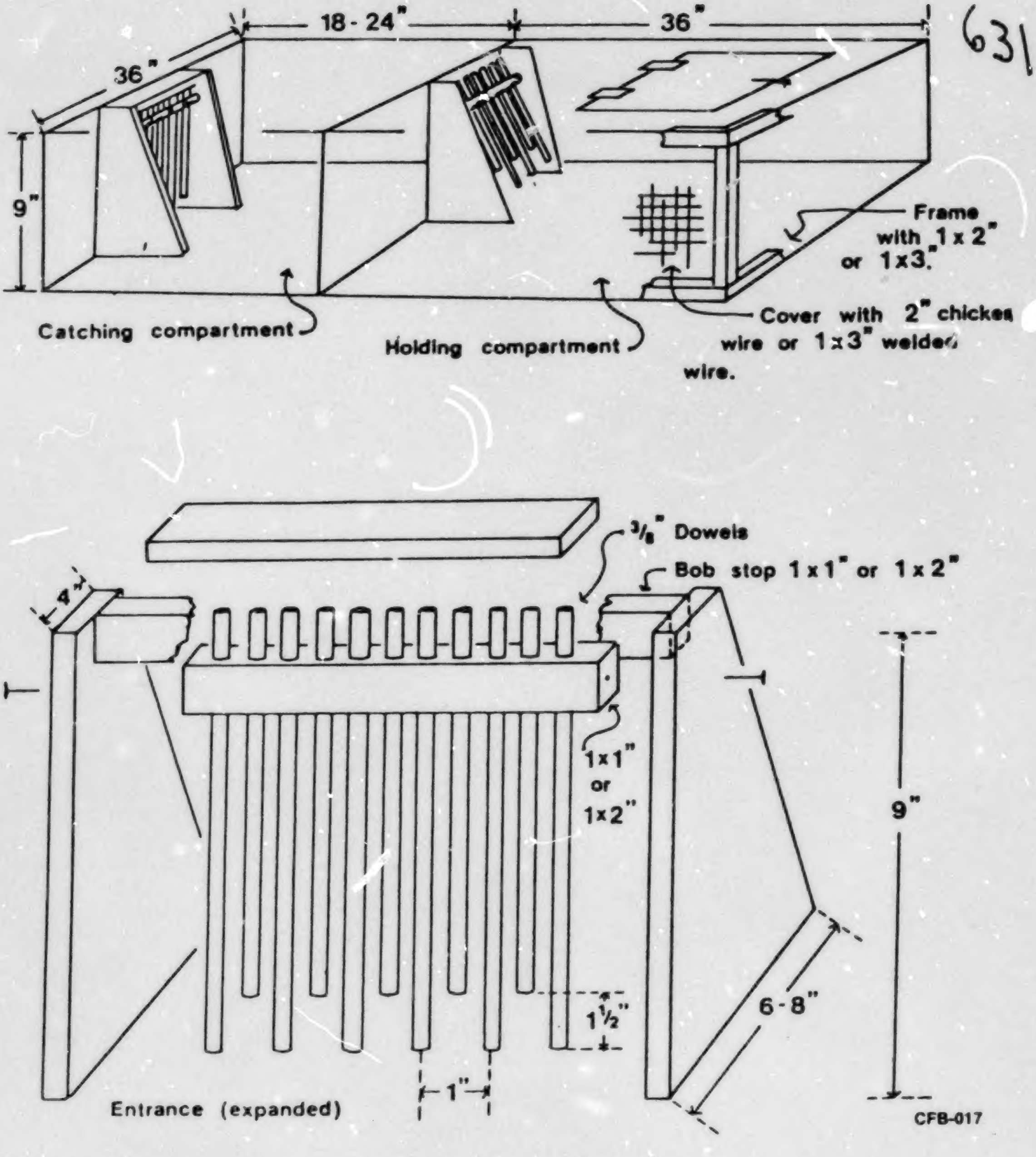
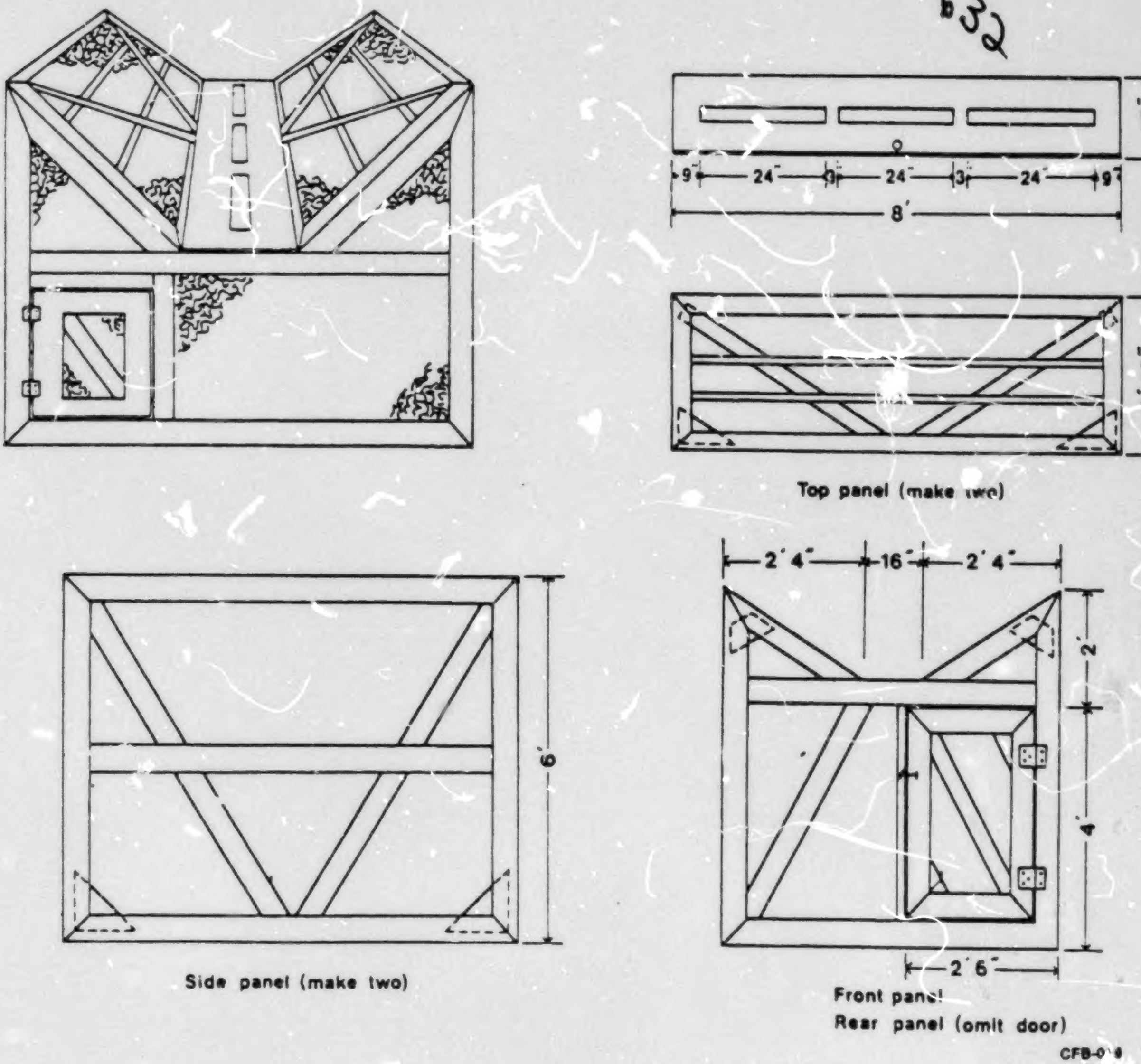

18 - 24"
36"
36"
9"
Frame with 1 x 2" or 1x3."
Cover with 2" chicken wire or 1x3" welded wire.
Catching compartment
Holding compartment
3/8" Dowels
Bob stop 1 x 1" or 1 x 2"
4"
1x1" or 1x2"
9"
6 - 8"
1½"
1"
Entrance (expanded)
CFB-017

Figure 1-14. Low-profile pigeon trap.

figure 1-15 was developed for starling control in orchards, but the trap has many other applications. It is very successful when used around buildings and other manmade structures and provides an appropriate means of capturing protected songbirds.

b. Traps should be at least 8 feet long, 6 feet wide, and 6 feet high, and even larger if practical. To ensure effectiveness and prevent escape, the 1.75 inch width of the entrance slots and 9 inch minimum clearance at both ends are critical. Place traps in the open rather than under trees. For starlings (as well as many other birds), the traps can be baited with rotting apples, finely cracked corn, or feed pellets. Try to bait with a food that the birds are accustomed to eating. If one trap location or type of bait is unsuccessful, try another. The trap will be most effective if decoy birds (10 to 12) are kept in the trap. It may be necessary to capture the first decoys by some other means. Provide the decoys with fresh water. Two suitable water containers can be created by splitting an old rubber tire down the middle. Traps should be tended regularly.



Top panel (make two)

Side panel (make two)

Front panel
Rear panel (omit door)

Figure 1-15. Modified Australian crow trap.

c. The modified Australian crow trap is probably the best live trap yet devised, simple and effective. Protected species usually can be released unharmed, while non-protected species can be killed or transported and released. Trapping large populations of starlings or other birds is impractical. It may be necessary to capture decoy birds by other means. The traps are large and may require disassembly before moving or storage.

Nest-box trap. This trap looks like a bird house. When a bird enters the box to investigate, its weight tips a device that drops it into a bag attached to the bottom of the trap. The trap is then automatically reset for another capture.

a. Nest-box traps are used to reduce local numbers of starlings or house sparrows during their breeding season. Nest-box traps come in several different designs. Plans for a trap designed to capture house sparrows are shown in figure 1-16. For starlings, the opening should be made 2 inches instead of the 1 1/2 inches used for house sparrows. When constructing the trap, the front wall should be put on last and fastened by screws instead of nails to make repair easier. Glue pieces of hay and feathers to the back of the chamber. Use a tightly woven sack to receive the birds as they are captured. Place the trap on the side of a building or on a pole where the sack can hang freely and be easily reached with the use of a ladder. The elimination of existing nesting sites by means of exclusion may increase the effectiveness of the traps.

b. In a limited area, nest-box traps can effectively remove house sparrows or starlings. Live-trapping is a humane method and does not involve the hazards associated with chemical repellents or poisons. Nest-box traps will probably not eliminate all the pest birds in any

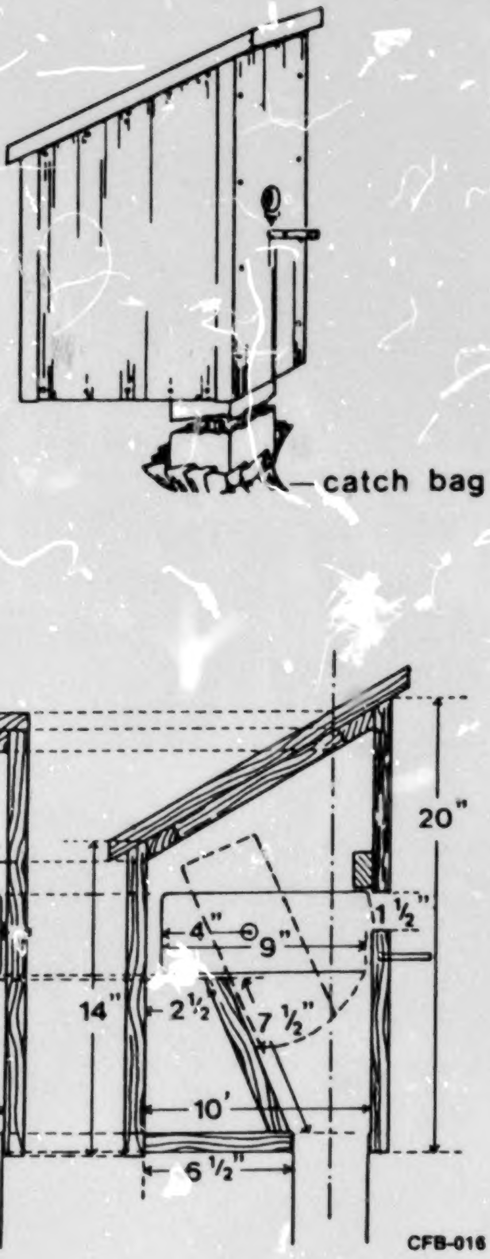

catch bag
20"
1 ½"
3 ½"
4"
9"
14"
2 ½"
7 ½"
4"
10'
6 ½"
CFB-016

Figure 1-16. Nest-box trap for house sparrows.

area. A continuous trapping program is required. Large-scale trapping programs for common pest species generally are considered impractical. These traps are effective only during the breeding season. This type of trap should not be used in areas where protected species (chickadees and bluebirds) are likely to be captured.

Raptor traps. A number of trap designs are available to capture raptors (hawks or owls). Two of the common designs are the Verbail pole trap and the Bal-Chatri. The Verbail snares birds of prey by the feet when they perch atop a pole. The Bal-Chatri uses nooses to entangle the feet of raptors that are attracted by live bait in a cage.

a. If hawks or owls create a strike hazard and cannot be discouraged from frequenting the area by other means such as elimination of their food supply, removal of perches, or putting sticky repellent or spikes on the perches, it is possible to trap them alive and release them elsewhere.

b. A raptor trapping program can be conducted only with the cooperation of the U.S. Fish and Wildlife Service. Fish and Wildlife Service personnel will provide the traps or the specific information necessary for construction. Verbail traps are set on top of posts. The raptor attempts to perch on the post, landing on a trigger plate which causes a spring to loop a cord around the bird's feet. The Fish and Wildlife Service also uses other types of pole traps specially adapted to capture birds of prey. The Bal-Chatri is a cage constructed of hardware cloth with the top covered by a number of slipknot nooses of monofilament nylon (fishing line). Different sizes of traps are used for different raptors. A live lure such as a mouse, starling, or house sparrow (or perhaps a rabbit, chicken, or pigeon for owls) is placed inside the cage. A raptor landing on the cage gets its feet tangled in the nooses. Raptor traps should be observed continuously or checked very frequently so that birds can be removed before they are injured. Captured birds should be transported for release at least 20 or 30 miles away to keep them from returning.

c. Trapping has no advantages over habitat modification or tactile repulsion techniques for discouraging raptors. The Bal-Chatri has several advantages in comparison to other raptor traps; specifically, it is simple, portable, easier to construct than the Verbail trap, and there is little danger of accidentally killing the birds. Trapping programs require considerable manpower and persistence. Other raptors may move in to replace those removed. Habitat modification (mowing to eliminate the habitat of the prey animals which attract the raptors and removal of perches) or use of tactile repellents on the perches is a better, more permanent solution to a strike hazard caused by raptors. Raptors are protected by Federal law, and permits are required to capture them. Raptor trapping programs must be conducted with the cooperation of the U.S. Fish and Wildlife Service.

Netting. Birds can be captured by various types of nets, including cannon nets, mist nets, and floodlight traps. The cannon net use rockets or mortar projectiles to carry a large, light net over a flock of birds attracted by bait. Mist nets are made of fine black nylon thread (like a hairnet) that virtually is invisible when set against a dark background. The mist net is strung between two upright poles, to capture birds in flight. The floodlight trap is a huge funnel-shaped net (supported by a frame) into which roosting birds can be driven. The funnel narrows down to a tent, lit by floodlights, which functions as a holding chamber.

a. The cannon net was designed to capture waterfowl but also has been used in other applications. Mist nets will capture small birds such as house sparrows, if the nets can be located to obstruct the birds' normal flight path. The floodlight trap was designed to capture starlings and blackbirds at their night roosts. Except in special circumstances, netting techniques are not likely to remove enough of the local population to be considered practical for bird control.

b. If you feel a particular pest situation warrants the use of a netting technique, the U.S. Fish and Wildlife Service should be contacted. This organization can supply information on the availability of cannon nets or floodlight traps in a given locality. Fish and Wildlife Service personnel also will cooperate with the PM in a control program using these techniques.

c. These netting techniques permit the capture of birds when other trapping techniques may be ineffective. Usually these techniques will not catch enough birds to effectively control a pest problem. Their use is limited and not practical for most Air Force bases.

Exercises (C25d):

1. Match the control method(s) in column B with the appropriate task described in column A. Some methods in column B may be used more than once.

Column A	*Column B*
____ (1) Trees in a military family housing area are thinned to eliminate roosting sites for passerines.	a. Altering the concept.
____ (2) Modified Australian crow traps are placed on top of aircraft hangars to reduce numbers of house sparrows roosting in the hangar.	b. Altering the situation.
____ (3) At a western U.S. installation, burrowing owls are inhabiting burrows from an abandoned prarie dog colony at the end of an active runway. Because of the hazard they present to aircraft, the burrows are plowed under to destroy the owls' nesting habitat.	c. Exclusion.
____ (4) Migratory waterfowl are using a lake next to the airfield. Because of the temporary nature of the situation, no action is taken to repel the birds.	d. Repulsion.
____ (5) Screening is installed in a hangar superstructure to eliminate roosting sites.	e. Removal.
____ (6) Gulls and crows are attracted to food openly disposed of in a dumpster at the installation commissary. Feeding is eliminated by placing open food waste in plastic bags before disposal.	

____ (7) Ring-billed gulls are using the airfield as a loafing and feeding area. The decision is made to reduce the food source by applying insecticides, using bioacoustics, and maintaining grass at 8-12 inches in height.

2. What is the most permanent solution to many pest problems near airfields?

3. What must you do first before cutting down trees containing active raptor nests?

4. Which type of exclusion technique should be used to eliminate water fowl and gulls from drainage ditches and other water areas?

5. Which type of exclusion technique is being used to prevent raptors from perching on runway marker lights?

6. Repulsion techniques are most effective with ______________ birds and are more effective with ______________ or ______________ birds than with those that are nesting.

7. In dispersing loafing gulls with recorded sound, what is the minimum distance the vehicle is driven to the birds?

8. What is likely to happen to birds when a distress call tape is allowed to run continuously?

9. List the characteristic that is essential to the 12-gauge shotgun when used to project scare cartridges.

10. When using pyrotechnics, what safety equipment must be worn?

11. When transporting M74A1 Airbursts, what type of warning device is used on the vehicle and how many are required?

12. What type fire extinguishers must always be available when using pyrotechnics, and how many are required?

13. Pyrotechnic devices are most effective when they are used in conjunction with what other repulsion technique?

14. What beneficial characteristic do gas operated exploders have as compared with 12-gauge shotguns or airburst?

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15. List the types of foods that should be used to bait live traps when starlings are the bird species to be caught.

16. At what minimum distance from the area trapped should nonprotected birds be released?

17. How can captured birds be marked to allow recognition of returning birds to the trapping area?

18. List the two common designs of raptor traps, and briefly explain how they operate.

19. Whom must you cooperate with before a raptor trapping program can be conducted?

C25e (C41 — for CE and feedback reference only.) Explain general principles of pest and hazardous bird surveys.

Before any bird problem can be controlled effectively and efficiently, it must first be identified and evaluated. For many types of pest bird problems, it is importantto For many types of pest bird problems, it is important to begin a control program while the problem is just beginning to develop or even before it begins. You should inspect the entire air base at least once a month throughout the year. During spring and fall, when birds are migrating through the area, daily spot checks are needed in addition to the monthly inspections.

Surveying a Bird Management Problem. In order to conduct an effective survey, you must establish certain objectives to guide you. Some suggestions that you may use are as follows:

Bird species identification. A primary objective of the survey is to properly identify bird species that may create damage problems or strike hazards. Some species or species groups (such as gulls and blackbirds) are more likely to become involved in pest situations than other birds and different birds will visit a given locality at different times of the year. During periodic surveys you should watch for the arrival of problem birds and to be ready to begin a control program before the birds establish a pattern for the season.

Existence of bird problems. The second objective of the survey is to determine if a problem exists. The presence of birds, even in large numbers, is not a problem unless the birds are creating a strike hazard, a health hazard of causing damage to buildings or equipment. If a problem exists, you must decide whether an active management program is needed. During migration, the

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birds may soon leave on their own. In other cases, the expense of a management program might exceed the cost of the damage that would result if nothing were done.

Identification of bird behavior patterns. Another objective of the survey is to specifically identify the behavior patterns of birds that are causing the damage or hazard. The PM must determine specifically *what* the birds are doing, *where* they are doing it and *when* they are doing it. For example, are birds a problem because they feed near the runway, attempt to nest in aircraft, or roost near a housing area? These are examples of bird behavior that may cause problems because of the location in which the birds carry out their activities. The time of day and time of year also can be important factors in the behavior patterns that must be identified during the surveys. *When* are the birds doing the feeding, nesting, or roosting that causes the problem?

Relationships between birds and the airdrome environment. Another objective of the survey is to analyze the relationship between the birds and the airdrome environment so that you can determine specifically what is attracting the birds that are causing the problem. Birds, in general, need four things: food, water, a place to nest, and a place to escape their enemies or avoid harsh weather. During the periodic surveys, you should determine which of these four things is attracting the problem birds. More than one factor could be important to any situation. However, quite frequently only one of these factors is the main attraction; if it can be eliminated by means of habitat manipulation, the pest problem will be solved.

Survey Checklist. Along with conducting surveys, you need to devise a checklist to maintain historical data on pest/hazardous bird species on your base. In addition to helping you identify and evaluate a pest problem and decide if active control is needed, these checklists document the inspection and should be saved for reference when future pest problems arise or when the same problem recurs. Pest problems change with time. Therefore, it is very important to fill out both the date and time of day at the top of the checklist. Weather conditions also should be recorded because they affect the bird activities. Some suggestions to help you devise a checklist are as follows.

Types of habitat. This item on the checklist can serve two purposes. First, you should list the different types of habitat present on your base. It should be noted here that bird habitats vary from base to base. Second, when spot checks are conducted in addition to the periodic complete inspections, this item permits you to check specific areas that were inspected.

Inspection of building features for evidence of pest birds. You should list building features (all types of ledges, ventilators, beams, rafters, etc.) that frequently are used for nesting or roosting by pigeons, starlings or house sparrows. For each feature, the species and number of birds seen and the presence of bird droppings or nest material can be indicated on the checklist during inspections of housing areas, hangars, and other buildings. Try to sketch the situation as well as describe it in words.

Other pest bird problem evidence. This item is used to document evidence of other types of potential damage or hazards such as reports or complaints, birds loafing or feeding on or near runways, and birds crossing the flight-path of aircraft. You personally should investigate complaints before beginning a control program.

Summary of birds observed. Here you should record the species numbers, location, and activity of birds observed during the inspection. Remember that a Federal permit is required before beginning a control program that might affect any protected bird species. A map of the airbase and surrounding area showing the locations of bird concentrations and attractive habitat features, as well as the movement patterns of the birds observed, can be used to supplement data recorded on your checklist. Figure 1-17 is a sample bird survey form (including a runway diagram) which could help document bird problems.

Economic damage and health or safety hazard. This item requires careful analysis of the situation. Is damage being caused that will cost money to repair, or is it just a nuisance situation? Is a hazard to aircraft or people being caused by the presence or activity of the birds?

Attraction of problem birds. You should check the ecological factor or combination of factors that attracts the birds to the particular locality where they are a problem. Careful field observation is required; do not jump to conclusions.

Length of bird problem. Here on your checklist you should record how long the problem has existed. Refer to checklists completed during previous inspections and ask questions of personnel who have been working in the area.

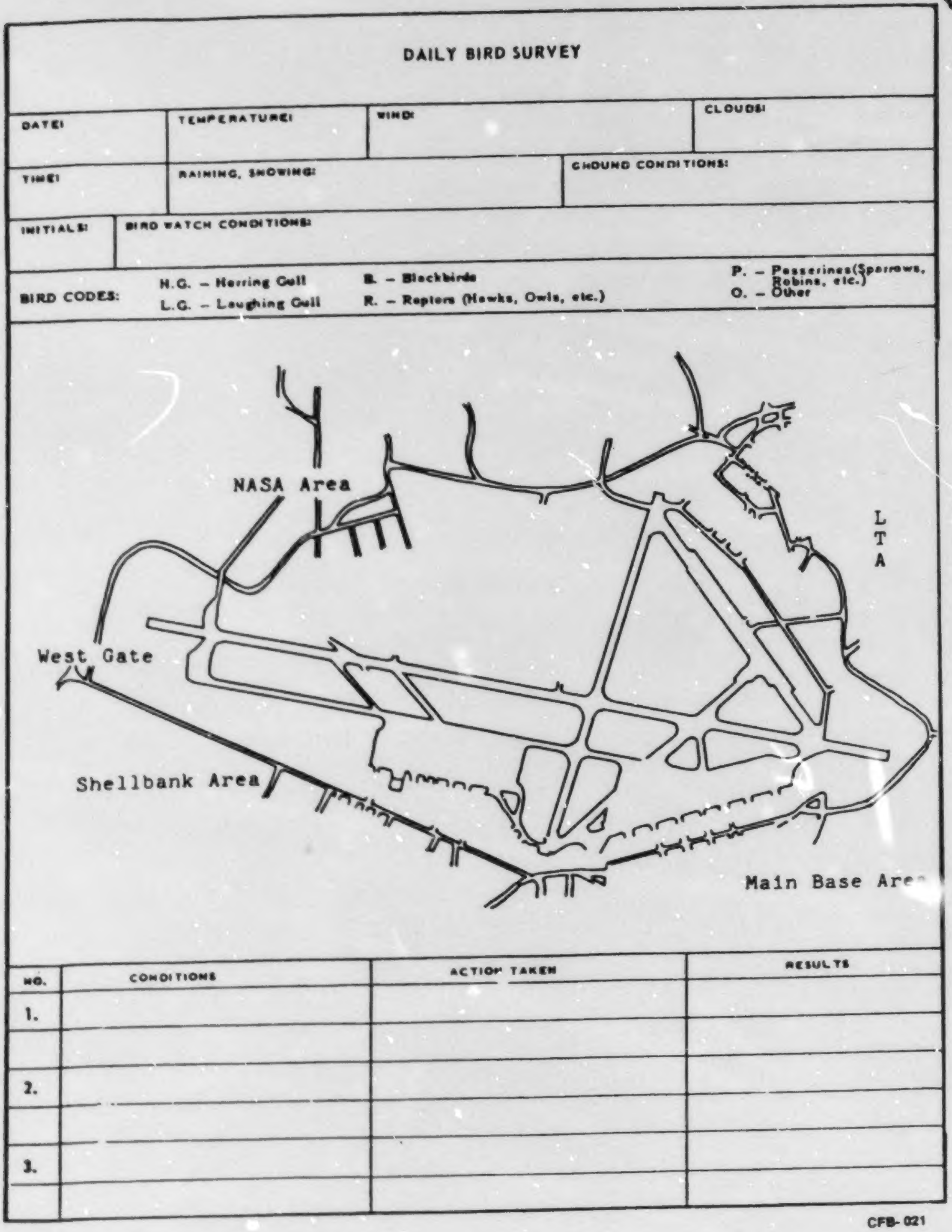
Season(s) of the year problems exist. This item is used in the same manner as the previous item, record the season or seasons of the year you encounter bird problems. Again, previous inspections will aid you.

Resident or transient birds. If you are in doubt as to whether the bird problem is caused by resident or transient birds, you may consult with State or U.S. Fish and Wildlife Service biologists who will, after complete identification of bird species, determine whether the birds are residents or just passing through the area. This answer will help determine the need for an active management program.

Time frame of bird problem. You should record the time of day when a problem occurs to help determine whether a strike hazard can be avoided by careful mission scheduling. A graph with bird numbers plotted against time of day will help evaluate this possibility.

Active management program. You need to evaluate the need for an active management program. Determine if the situation warrants the time and expense. Consider the alternative of taking no action, and predict what would happen. Take all available evidence and past experience into account, and do not jump to conclusions. If you are not sure, say so, and collect more information.

Management approaches. Here you should check each approach to management (control) as consideration is given to it. This should be done with reference to behavioral objective C25d, which describes the various



DAILY BIRD SURVEY

DATE:

TEMPERATURE:

WIND:

CLOUDS:

TIME:

RAINING, SNOWING:

GROUND CONDITIONS:

INITIALS:

BIRD WATCH CONDITIONS:

BIRD CODES:
H.G. – Herring Gull
L.G. – Laughing Gull
B. – Blackbirds
R. – Raptors (Hawks, Owls, etc.)
P. – Passerines (Sparrows, Robins, etc.)
O. – Other

NASA Area
LTA
West Gate
Shellbank Area
Main Base Area

NO.	CONDITIONS	ACTION TAKEN	RESULTS
1.			
2.			
3.			

CFB-021

Figure 1-17. Sample bird survey form.

techniques available within each of the five approaches. Consider each approach in turn, and reject only those that contain no acceptable technique for the specific problem at hand.

Exercises (C25e):

1. For the many types of pest bird problems, when is it most appropriate to start control program?
2. What two characteristics should you employ to anticipate the arrival of problem birds?
3. Briefly explain why bird behavior patterns may cause problems.
4. Briefly explain the four factors that could attract birds to the airdrome environment and, if possible, what method of elimination should be used to solve the problem?
5. Explain why a survey checklist is essential in relationship to bird problems.

CHAPTER 2

Vegetative Pests

WEEDS ARE "PLANTS out of place." For example, a farmer who raises wheat takes pride in a good stand. Yet, the farmer's wife will quickly extract the same plant from her zinnia bed.

On an Air Force base or installation, there are areas where plants are desirable, including lawns, golf courses, road embankments, railroad right-of-ways, and runway shoulders. In these areas we control the weeds.

There are also areas where any vegetation is undesirable. Some of these areas are around fuel, oil, and paint storage areas; certain buildings and shops; under fences; and along roads and railroads. Some vegetation control along drainage and irrigation ditches is also required.

This chapter covers the growth habits and propagation of plants and describes important aquatic, woody, grassy, and herbacious broadleaf plants and their control.

2-1. Weed Growth and Propagation

This section covers the growth habits and propagation of plants in general to provide you with a basis for further discussion of aquatic and other types of plants and their control.

C26. List and explain briefly the growth characteristics that enable weeds to persist.

Growth Characteristics. The most important growth characteristic of weeds is their ability to thrive in cultivated land. Other features that contribute to the successful growth of unwanted plants and to their ability to persist in spite of human efforts to the contrary include:

- Underground roots or stems.
- Abundant seed production.
- Rapid growth.
- Competitive ability.
- Unpalatability to livestock.

Underground roots or stems. Unwanted plants with underground roots or stems will persist from year to year even though seed production is prevented. The underground parts of some plants will spread in all directions, sending up aerial stem buds at intervals. These plants are spread and actually favored by cultivation, since cultivation spreads small pieces of roots over other areas.

Abundant seed production. Many plants can produce thousands of seeds, and some of these seeds can live in the soil from 10 to 50 years.

Rapid growth. Some plants (weeds) are capable of growing to maturity and setting seed within a short period of time (1 to 2 months). For this reason, seeds are formed before adequate control measures can be established.

Competitive ability. Some plants can overtake and retard other plants even though the latter have a headstart. For this reason, they are often successful in outcompeting other plants for light. In addition, certain weeds have requirements for mineral nutrients and water that exceed those of desirable plants.

Unpalatability to livestock. Frequently, pasture weeds are distasteful or poisonous to animals. Often they are protected by spines or similar structures. For these reasons, they are free to reproduce and spread unimpeded to areas where they are even less desirable.

Exercises (C26):

1. What is the most important growth characteristic of weeds?

2. List other growth characteristics of weeds and explain briefly why they enable weeds to persist.

C27. Associate the names of certain plants with statements pertaining to their propagation and identification.

Annuals. Annuals are plants that mature in one season. They are propagated by seed. Foxtail, crabgrass, ragweed, wild buckwheat, and several mustards are examples.

Foxtail. The foxtails are grasses of roadsides and waste places. They are striking plants because of their dense, cylindrical, spikelike inflorescences (seed heads). The yellow foxtail is shown in figure 2-1. This plant is distinguished by the tawny color of the spikes.

Crabgrass. An example of crabgrass is shown in figure 2-2. Crabgrass is an annual plant that flourishes midsummer to fall. It is highly branched with the stem prostrate and rooting. The inflorescence is a terminal cluster of spikes. The seeds are slightly hairly.

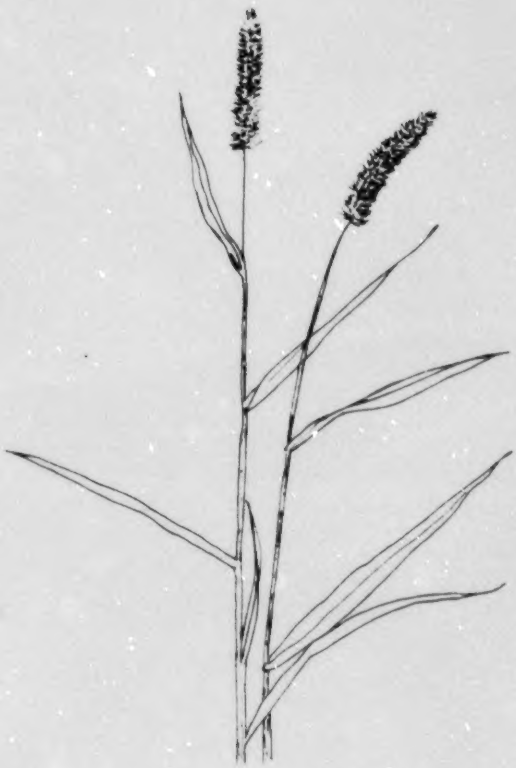


Figure 2-1. Yellow foxtail.

Ragweed. You have probably come in contact with ragweed sometime during your life. The ragweed is one of the plants that gives hayfever sufferers much trouble. You can see this plant in figure 2-3. The ragweed is an annual weed of rural and urban waste areas. The plant is erect and branched and, depending upon the species, may be from 1½ to 3½ feet tall. The leaves (pennate) are formed of leaf parts arranged featherlike along each side of a leaf stem. They show a great deal of variation from species to species. The yellow flowers are borne on tall spikes.

Wild mustard. This plant, shown in figure 2-4, is an annual weed of waste areas and cultivated ground. It is a low plant with many branches. The four-petaled yellow flowers develop into numerous siliques (capsulations). These contain the smooth, black, globular seeds.

Shepherd's purse. This weed, shown in figure 2-5, is one of the most widely distributed weeds in the world. This plant can be either an annual or a winter annual (germinates in the fall, lives over winter, and matures early the next season) in lawns, gardens, or waste areas. The plant has a basal rosette of deeply toothed leaves, with a few arrow-shaped leaves on the erect stalk. The seed pods or "purses" are also on the stalk. The seed pods form from terminal white flowers, and they contain numerous yellowish seeds.

Biennials. Biennials require two seasons to complete the reproduction cycle. Their growth period is longer than that of winter annuals. Since they are propagated by seed only, seedlings can be treated as the seedlings of annuals.

Common mullein, shown in figure 2-6, is also known as Jacob's staff, torch plant, and flannel leaf. Common mullein is a biennial, and it produces its rosette of velvety basal leaves in the first year. In the second year, it sends up its stalk on which is borne a terminal spike of yellow flowers. Burdock, evening-primrose, common mullein and yellow goatsbeard are biennials.

Perennials. Perennials are plants that live more than 2 years. Many have several means of perpetuation. They are provided with storage organs in the form of stolons (prostrate stems), rhizomes (underground stems), bulbs, crowns, and roots. The perennial weeds with creeping roots or stems are the most noxious. Supplies of food are laid up in these organs by the plant to feed a new growth the next year. The new shoot comes from a bud and lives on stored food until it becomes established. Unlike the annual plant, the topgrowth of a perennial may be killed and still the plant can live and propagate itself because of its

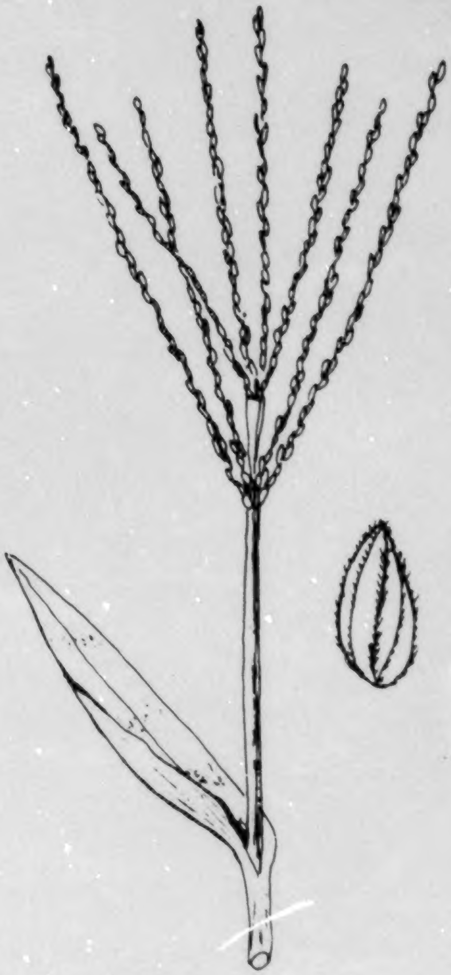


Figure 2-2. Crabgrass.

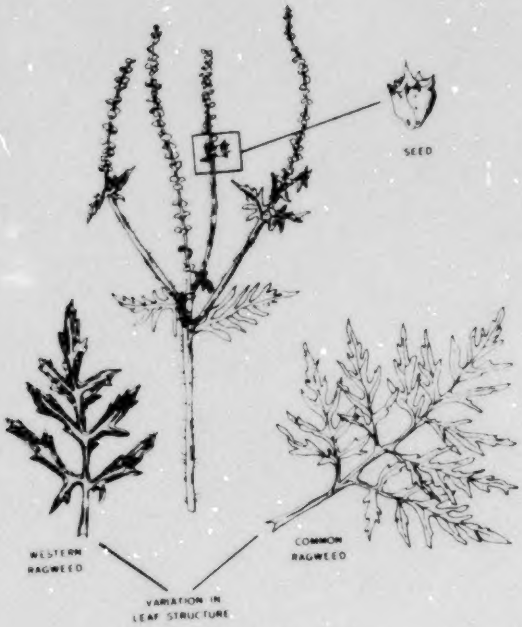

SEED
WESTERN RAGWEED
COMMON RAGWEED
VARIATION IN LEAF STRUCTURE

Figure 2-3. Ragweed.

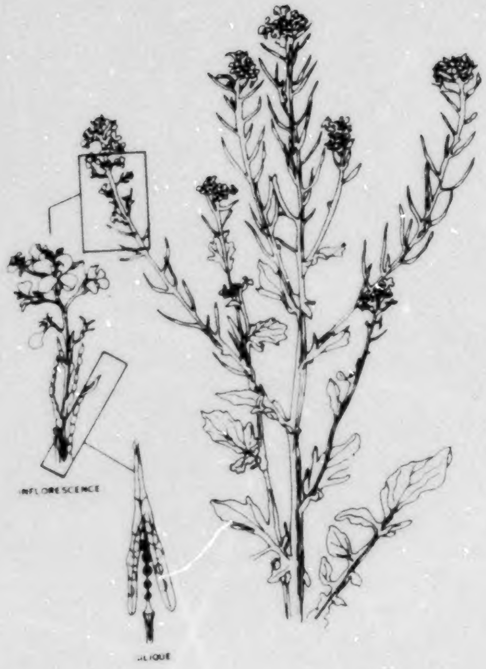

INFLORESCENCE
SILIQUE

Figure 2-4. Wild mustard.

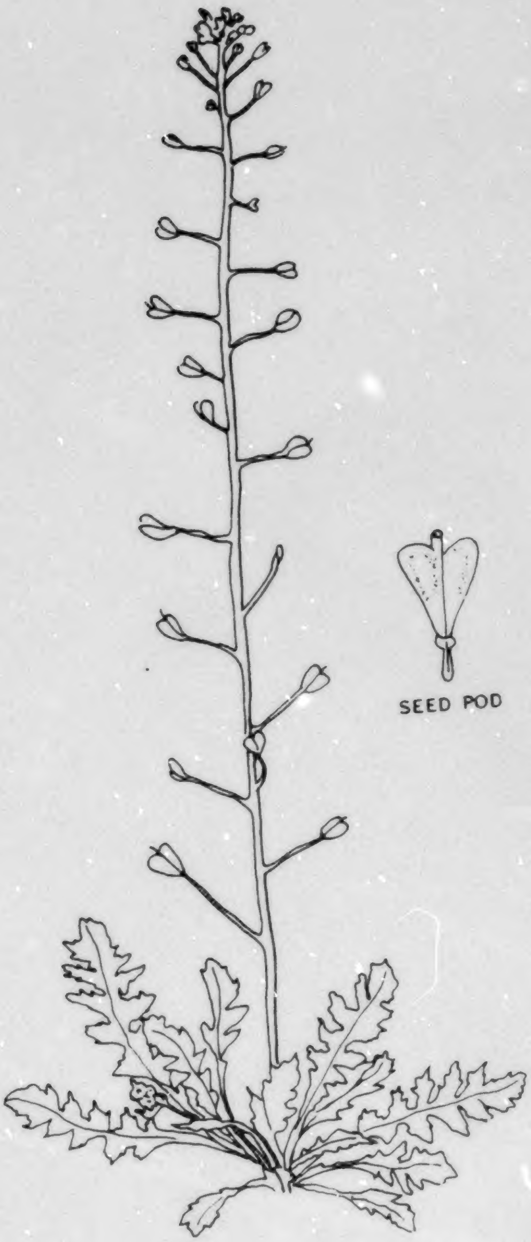


Figure 2-5. Shepherd's purse.

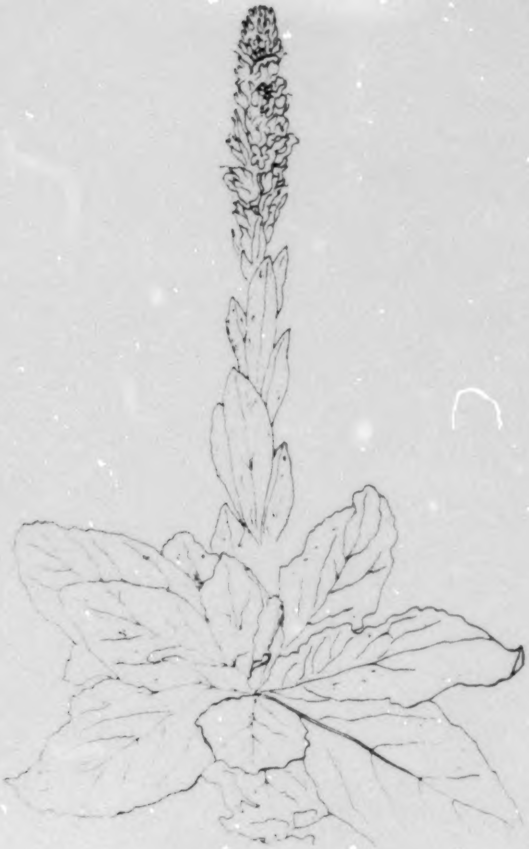


Figure 2-6. Common mullein.

storage organs. To control this vegetative reproduction, the food reserves must be materially reduced or the storage organs destroyed. The food stored by the plant is the excess manufactured by the green leaves and stems over and above what is necessary for growth; therefore, if photosynthesis can be prevented, the buildup of reserves will be curbed. For control of perennials, the new growth is allowed to draw on food reserves until it becomes sufficiently established to manufacture its own food and then the topgrowth is killed. Quackgrass, Canada thistle, Johnson grass, buttercup, and nutgrass are perennials.

Canada thistle. This plant is possibly the most noxious perennial weed in the United States. It grows up to a yard high, with grooved, hairy stems and irregularly lobed or toothed leaves. The root system is deep, wide, and spreading. The plant blooms in late spring and summer, depending upon location, and produces small lavender flower heads. Figure 2-7 illustrates the Canada thistle.

Johnson grass. Another weed is Johnson grass. Johnson grass, shown in figure 2-8, is a perennial weed posing a big problem in the southern part of the United States. It is 3 to 6 feet tall, and has wide leaves with a thickened, light-colored midvein. The panicle is loose and turns reddish at maturity.

Buttercup. This weed is most commonly found in shady, moist areas, such as pastures, woodlands, and ditches. Notice in figure 2-9 that the stems are slender and branched from the base. The lower leaves are round, on long petioles, and the upper leaves are often divided into leaflets. The flowers are small and yellow.

Yellow nutgrass. This weed, shown in figure 2-10, is a perennial weed infesting lawns. Its name comes from the nutlike tubers found on the roots of the mature plants. The stem is yellow-green and triangular in cross section. When you look down on the plant, the leaves appear in three ranks, corresponding to the three sides of the stem.

Exercises (C27):

1. Match the plant types in column B with the statements pertaining to the propagation and identification of plants in column A.

Column A

___ a. Annual weed of waste areas and cultivated ground, with four pleated yellow flowers containing smooth, black, globular seeds.

___ b. Possibly the most noxious perennial weed in the United States. It grows up to a yard high, with grooved hairy stems and irregularly lobed or toothed leaves.

___ c. The stem is yellow-green and triangular in cross-section.

___ d. Most commonly found in shady moist areas, such as pastures, woodlands, and ditches.

___ e. Gives hayfever suffers much trouble.

___ f. One of the most widely distributed weeds in the world. The seed pods form from terminal white flowers and contain numerous yellowish seeds.

___ g. Also known as Jacob's staff, torch plant, and flannel leaf.

___ h. Highly branched with the stem prostrate and rooting. The inflorescence is a terminal cluster of spikes; the seeds are slightly hairy.

___ i. Grasses of roadsides and waste places. They are striking plants due to their dense, cylindrical, spikelike inflorescences.

___ j. Three to 6 feet tall, and has wide leaves with a thickened, light-colored midvein.

Column B

1. Shepherd's purse.
2. Canada thistle.
3. Yellow nutgrass.
4. Foxtails.
5. Wild mustard.
6. Common mullein.
7. Buttercup.
8. Crabgrass.
9. Johnson grass.
10. Ragweed.

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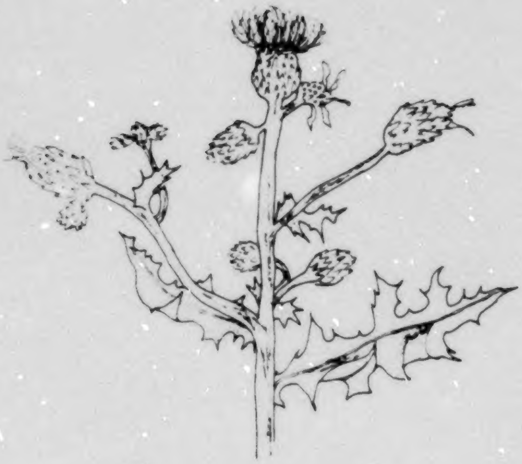

Figure 2-7. Canada thistle.

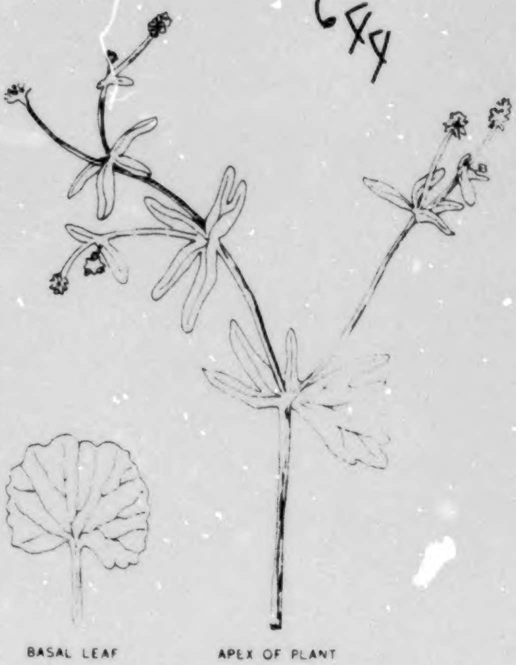
BASAL LEAF
APEX OF PLANT

Figure 2-9. Buttercups.

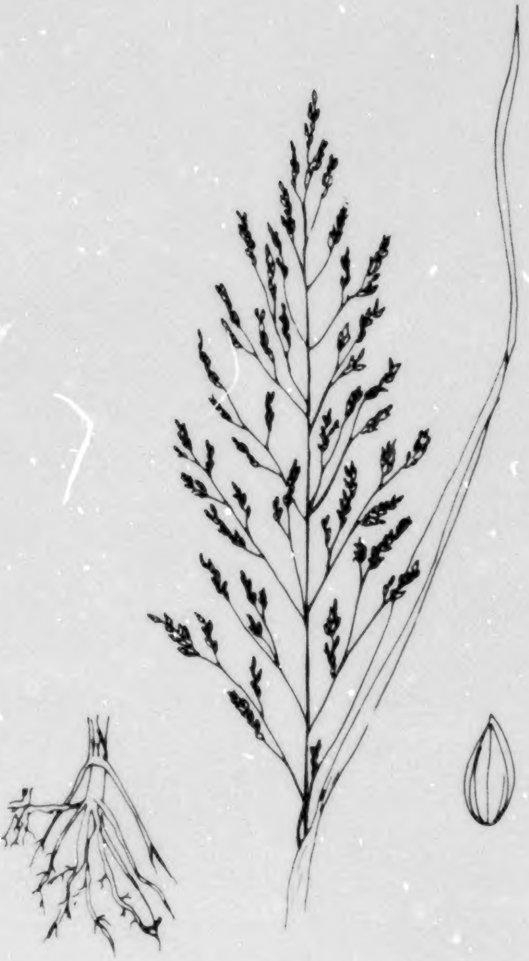

Figure 2-8. Johnson grass.

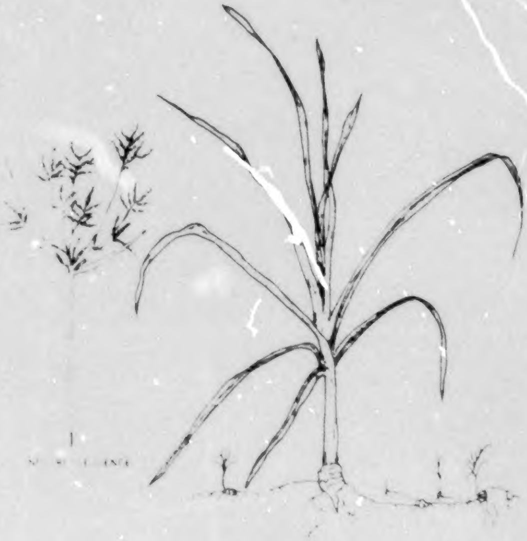
YOUNG PLANT

Figure 2-10. Yellow nutsedge, yellow nutgrass.

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2-2. Aquatic Plants

Aquatic plants are becoming a major problem within the United States. Almost everyone becomes concerned with aquatic plants at one time or another because each body of water from roadside ditches to the largest lakes support aquatic vegetation. Control of these plants is essential in all aspects of water use, including irrigation, drainage, animal consumption, recreation, pollution, and public health.

C28. Distinguish between correct and incorrect statements that pertain to the growth and characteristics of aquatic plants, and explain why the incorrect ones are not true.

Types, Growth, and Characteristics of Aquatic Plants. As the term implies, aquatic plants are plants that grow in water. These same plants become recognized as aquatic weeds when they interfere with the intended use of the area in which they are located.

Aquatic plants are generally classified into three groups: (1) floating, (2) submersed, and (3) emersed.

Floating plants. Floating plants are plants that germinate in the bottom of a body of water at first and, soon after germinating, become separated from the soil and float on the surface of the water. Once they have become separated from the soil, they are no longer dependent upon the soil.

Submersed plants. Submersed plants are aquatic plants that complete their entire life cycle below the water surface. However, some of these plants may have floral parts that extend above the water surface. Most of these plants are rooted, but some, such as algae, are not rooted.

Brazilian elodea, widgeongrass, common bladdewort, vallisneria, coontail, marine naiad, and broadleaf watermilfoil are examples of common rooted submersed aquatic plants.

Emersed plants. Emersed plants are plants that are firmly rooted to the soil on the bottom of bodies of water. During normal growth, these plants extend above the water surface.

Spatterdeck, fragrant waterlily, American lotus, watershield, pickerelweed, arrowhead, buttonrush, cattail, softstem bulrush, softrush, maidencane, torpedograss, sawgrass, foxtail, and reed are common examples of emersed aquatic plants.

Exercises (C28):

Identify the following statements as being correct (C) or incorrect (I). Explain any incorrect statements.

___ 1. Floating plants germinate at the bottom of a body of water and float to the surface, but are still dependent upon the soil.

___ 2. Submersed plants are aquatic plants that complete their entire life cycle below the surface of the water.

___ 3. Some submersed plants have floral parts above the water surface.

___ 4. Emersed plants are firmly rooted to the soil on the bottom of bodies of water and no part of the plant shows above the surface.

C29. Complete given statements concerning mechanical, biological, and chemical measures that may be implemented for controlling aquatic vegetation.

The control of aquatic plants is based upon the type and location of the plants to be controlled. Controlling aquatic plants presents many problems for you because controls often affect other aquatic life. Although chemical control methods are most popular, most aquatic plants can be controlled effectively by mechanical methods, even though these methods are generally more expensive and slower than chemical methods. Biological control is also used on a limited basis.

Mechanical Control. Mechanical control methods for aquatic plants include pulling, chaining, dredging, drying, burning, and moving. The methods you use should depend on the size of the area, type of terrain, and availability of equipment and operators.

Pulling or raking. Small bodies of water can be temporarily rid of aquatic plants by hand pulling or raking the plants from the water.

Chaining. Aquatic plants can be removed from canals and drainage systems by dragging a heavy chain between two tractors on opposite banks. The chain should be towed in one direction and then back in the opposite direction to be most effective. Dragging the chain through the water will detach rooted submersed plants and emersed plants from the bottom of the body of water. Once these plants have been detached from the bottom they should be removed from the water by raking.

Dredging. Dredging seems to be equally effective for all types of aquatic vegetation but must be used very cautiously. Equipment used for dredging should be equipped with weeding forks instead of the normal bucket. Although dredging operations are very effective for removing aquatic vegetation, they are not very advantageous in other aspects. Removing vegetation by dredging also removes mud along with the weeds, therefore enlarging and deepening the water holding area causing a change in capacity.

Drying. Many submersed aquatic weeds, especially those in hot, arid regions may be controlled effectively by drying. This method is often objectionable because it requires complete drainage of the area, which, in most instances, must be accomplished when the water is needed the most.

Burning. Burning is an effective mechanical control measure for controlling young succulent plants along canals and drainage ditches. Burning is most generally accomplished by searing the plants first, then finishing the burn a week or two later.

Mowing. Providing banks are smooth enough, not too steep, and relatively unobstructed, mowing can be used to control aquatic vegetation growing along the sides of canals and drainage systems. Specially designed power-driven weed saws and weed cutters can be used to control rooted submersed plants and emersed plants within bodies of water.

Chemical Control. Approved chemicals may be applied in the form of sprays or granules. Porous bags that contain chemicals can be dragged through the water until the chemical has dissolved. Chemicals can even be applied over iced areas in the same manner you would treat a field. As the ice melts, the chemical is released slowly into the water. Copper sulfate, if applied correctly, can be used and is very effective for controlling algae. Aromatic oils are also often used for controlling aquatic weeds in irrigation canals. Additional chemicals and applications for controlling aquatic vegetation are provided in Appendix A of the supplement to Volumes 4, 5, 6, and 7.

Biological Control. There are certain fish and snails that feed on many aquatic weeds and, at times, they will virtually eliminate aquatic weeds in ponds and lakes. Carp and sunfish are very important in reducing aquatic vegetation and the *Marisa cornuarietis* snail has shown promise in controlling aquatic weeds in Florida.

Exercises (C29):

1. Pulling, chaining, dredging, drying, burning and mowing are examples of ______ control of aquatic plants.
2. The methods used will depend on the ______ of the area, type of ______, and availability of ______ and ______.
3. Aquatic plants can be removed from ______ and ______ systems by dragging a heavy ______ between two ______ on opposite banks.
4. Dragging a chain through the water will detach ______ submersed plants and ______ plants from the bottom of a body of water.
5. When chaining aquatic plants, the chain should be towed in one direction and then ______ in the ______.
6. Once plants have been detached from the bottom, they should be removed by ______.
7. Equipment used for dredging should be equipped with ________ ________ instead of the normal ________.
8. Removing vegetation by dredging also removes ______ along with the weeds, therefore enlarging the water holding area causing a change in the ______.
9. The drying method for control of aquatic vegetation is objectionable because it requires ______ ______ of the area.
10. Burning is most generally accomplished by ______ the plants first then finishing the ______ a week or two later.
11. Mowing can be used to control aquatic vegetation growing along the ______ of canals and drainage systems.
12. Specially designed power-driven ______ ______ and weed ______ can be used to control rooted submersed plants and ______ plants within bodies of water.
13. Approved ______ may be applied in the form of ______ or ______.
14. ______ bags that contain ______ can be ______ through the water until the chemical has ______.
15. There are certain ______ and ______ that feed on many aquatic weeds and, at times, will virtually ______ those weeds in ponds and lakes.

2-3. Woody Plants

For the most part, woody plants that occur on Air Force bases have been planted or left alone to aid in base beautification or as wind breaks. In most cases, woody plants are more of a problem in forestry and range management; however, they can be a serious problem along streets, fence rows, ditchbanks, railroads, power lines, and water and sewer distribution systems.

This section provides you with the general growth and characteristics of woody plants and outlines the general control measures that you can use to control woody plants when necessary.

C30. Discriminate between true and false statements pertaining to the characteristics and control of woody plants, and correct those that are false.

Characteristics and Control of Woody Plants. Woody plants are plants that have thick trunks, relatively sturdy branches, and bark-like coverings. Woody plants include trees, shrubs, and vines. Trees are normally regarded as being large woody plants that have a single stem or trunk for self-support and several branches. Shrubs have the same characteristics that trees have but are generally not more than ten feet in height. Vines are woody plants that climb or sprawl and do not have a self-supporting trunk.

Woody plants have extensive root systems. Some of these plants have sprawling roots, others have a deep root system, and still others have both types.

Stump, basal-bark, and foliage applications are most suitable for the control of brush and trees along roadsides and utility lines.

Stump applications are most satisfactory for killing trees along roadsides and controlling brush over 0.9 meters tall. Considerable labor is required, but the danger from falling branches is removed and there are no standing dead trees. Use esters of 2,4,5-T or 2,4-D plus 2,4,5-T at any time of year or ammonium sulfamate during the growing season. Sodium arsenite can be used where the hazards of poisoning are not important.

Basal applications are practical for uncut brush and for regrowth from cut brush or trees. Make applications during the dormant season to avoid danger of injury from drift. Use esters of 2,4,5-T or 2,4-D plus 2,4,5-T.

Applications made in frills or girdles are more effective than basal treatments on large or thick-barked trees, and they prevent sprouting more effectively than stump treatments. Use 2,4,5-T or 2,4-D plus 2,4,5-T. Apply ammonium sulfamate and sodium arsenite in the same manner as for stump treatments.

Exercises (C30):

Identify the following statements as true (T) or false (F). Correct the false statements.

___ 1. Woody plants are plants that have thick trunks, relatively sturdy branches and bark-like coverings.
___ 2. Woody plants include trees, shrubs, and vines.
___ 3. All woody plants are self-supporting.
___ 4. Shrubs and trees have the same characteristics.
___ 5. Woody plants have either deep roots or sprawling roots.
___ 6. Stump applications are most satisfactory for killing trees along roadsides and for controlling brush over 0.9 meters tall.
___ 7. Very little labor is involved with the stump application.
___ 8. Sodium arsenite is the best treatment where wild life is present
___ 9. Basal applications are practical for uncut brush and for regrowth from cut brush or trees.
___ 10. Basal applications should be made during the dormant season to avoid danger of injury from drift.

2-4. Grasses and Herbaceous Broadleaf Plants

Even though grasses are quite beneficial to humans, they can become pests when they are in the wrong places. When this occurs, grasses become weeds and must be controlled. To do your job, you must be knowledgeable of the characteristics and controls of grasses.

Herbaceous broadleaf plants are the plants that most people consider to be the true weeds. This section describes both herbaceous broadleaf weeds and grasses so that you can distinguish them from other plants and each other. This section also discusses the various control measures that you can use to control both grassy plants and herbaceous broadleaf plants.

C31. Indicate whether given statements pertaining to the general characteristics and controls for grasses are true or false.

Characteristics and Control of Grasses. Grasses are plants that have long, thin, narrow leaves and that usually grow more outward along the ground than upward. Regardless of whether the long, thin, narrow-leafed plant is tall or spread along the ground, you can recognize it as a grass if it has sheathing at each leaf base. Most grasses are monocots (they have only a single cotyledon). The cotyledon is a tiny leaf-like structure that emerges from the germinated seed. Grasses have fibrous root systems and tend to be both perennial and annual. Probably one of the best and most easily recognized characteristics of a grass is the parallel venation of the leaves.

As in all other cases involving the control of pests, grass controls depend upon the species and location. Other factors that bear on the controls are the region in which the grass is growing, type of soil in which it is growing, and weather conditions. Grasses may be controlled through biological, mechanical, and chemical control measures.

Chemical controls for specific grasses in specific areas are identified in Appendix A of the supplement to Volumes 4, 5, 6, and 7.

Exercises (C31):

Identify the following statements as being true (T) or false (F).

___ 1. A plant can be recognized as grass by having sheating at each leaf base.
___ 2. Grasses have fibrous root systems and tend to be both perennial annual.
___ 3. Grasses are described as plants with long, thin, narrow leaves that grow more outward along the ground than upward.
___ 4. No grasses grow more upward than outward.
___ 5. Most grasses are polycots.
___ 6. The tiny leaf-like structure that emerges from the germinated seed is called a monocot.
___ 7. Grass controls are dependent upon the species and where it is located.
___ 8. Region, weather, and type of soil have little to do with control measures.

C32. Complete given statements concerning the general characteristics of herbaceous broadleaf plants.

Characteristics of Herbaceous Broadleaf Plants. There are some general characteristics that you can use to separate broadleaf and grassy weeds. Most broadleaf plants have relatively wide leaves, comparatively speaking, and the leaves have a netted venation. In broadleaf plants, there are normally clusters of leaves at the ends of branches and growth of the plants extends from growth nodes located at the end of branches. Broadleaf plants most generally tend to be dicots, which means that two leaf-like structures (cotyledons) appear immediately following seed germination. The root system of herbaceous broadleaf plants is relatively deep and strong. The root system consists of a tap root with many small lateral roots extending from it.

Exercises (C32):

1. Most broadleaf plants have relatively ________ ________ and the leaves have a ________ venation.
2. In broadleaf plants, there are normally ________ of leaves at the ends of branches and growth of the plants will extend from growth ________ located at the ends of ________.
3. Broadleaf plants most generally tend to be ________, which means that two leaf-like structures appear immediately following seed ________.
4. The root system of herbaceous broadleaf plants is relatively ________ and ________.
5. The root system consists of a ________ root with many small ________ roots extending from it.

C33. Identify as correct or incorrect given statements pertaining to the biological and mechanical control measures for grasses and herbaceous broadleaf plants.

These plants may be controlled through biological, mechanical, and chemical measures. Although the biological and mechanical controls are generally slower and more expensive than chemical controls, they should be implemented whenever and wherever possible.

Biological Control. In order for applied biological controls to be effective, the predators or parasites introduced must feed only on the weed species you want to control. The predators and parasites you use in the control should not be a food source for other living organisms within the area. In addition, they must be adapted to the surroundings and have the ability to find the host. Biological control is often the only control available for controlling weeds in inaccessible areas.

Biological control of grass and herbaceous broadleaf weeds include the use of certain insects, arachnids, fowl, grazing animals, and other plants.

Control by insects. The goatweed beetle has been used successfully for controlling the rangeweed *(Hypericum perforatum)* in many areas of California and the Pacific Northwest. The cactus moth is very effective for controlling prickly pear cacti. The flea beetle has shown promise in controlling the Canada thistle in areas of Canada and the Pacific Northwest.

Control by fowl. Geese are used in many instances to control young weeds in such crops as cotton, strawberries, and mint.

Control by grazing animals. This concept is based on the placement of grazing animals that prefer the plants desired to be controlled into the infested area.

Control by other plants. Some degree of success in controlling undesirable vegetation has been obtained by certain plants in producing selective phytotoxins. For example, black mustard was planted in regions of California to inhibit the germination of Chaparral, an undesirable range plant, but did not inhibit other range plants that were desired.

Mechanical Control. Grasses and herbaceous broad-leaf plants can be controlled effectively through mechanical measures if the right measure is implemented at the right time. The proper mechanical control and the appropriate time for controlling plants depends on whether the plants are annuals, biennials, or perennials.

Control by cultivation. In most cases, cultivating is the most practical mechanical control for controlling annual and biennial weeds when the area is cultivated shallow in early spring and frequently thereafter until midsummer. This process reduces competition to desirable crop plants and prevents flowering and seeding.

Cultivating undesirable perennial plants will cause the plants to starve because cultivation will prevent the plants from manufacturing additional food. It will also cause them to expend the food that is already stored within the plant. Controlling perennial plants through cultivation should be accomplished shortly after the plants have produced new foliage.

Control by mowing. Mowing is relatively effective for controlling some species of annual weeds if you mow often enough and before the flowers mature. Mowing should be conducted at a height that is low enough to remove the flora but high enough to still permit competitive ability.

Control by burning. Although burning is an unpopular word among environmentalists, it does have some merit in the control of undesirable vegetation. Fire is more effective for controlling annual plants than perennials. Buring is a useful mechanical control measure for removing vegetation along fire breaks, waterways, railways and security fences. Burning of vegetation is a popular practice in tropical regions because the ashes provide additional nutrients to the low nutrient soils generally found in tropical regions.

Control by mulching. Mulching keeps light from the plants. Photoshythesis is thus reduced and the plants die or do not grow. Materials used for mulching include sawdust, hay, straw, manure, paper, and plastic. The area being treated must be completely covered with mulch. The layer of mulch must be thicker for perennials than for annuals. Deep-rooted perennials, such as morning-glories, may require a layer of mulching material 3 to 4 feet thick.

Exercises (C33):

Identify the following statements as being correct (C) or incorrect (I).

___ 1. These plants may be controlled by biological, mechanical, or chemical measures.

___ 2. Biological and mechanical controls are slower but less expensive than chemical controls.

___ 3. In order for bilogical controls to be effective, the predators or parasites introduced must only feed on the weed species desired to be controlled.

___ 4. Biological control of grass and herbaceous broadleaf weeds includes the use of certain insects, arachnids, fowl, grazing animals and other plants.

___ 5. The goatweed beetle has been used to control the prickly pear cacti.

___ 6. The flea beetle has shown promise in controlling the Canada thistle.

___ 7. Geese are used to control young weeds in crops.

___ 8. Plant control by other plants is not practical since most of the controlling plants are undesirable.

___ 9. An important consideration in mechanical plant control is whether the plants are annuals, biennials, or perennials.

___ 10. Plant control by cultivation is one of the most practical mechanical methods.

___ 11. Controlling perennial plants through cultivation should be accomplished shortly before the plants have produced new foliage.

___ 12. Mowing should be done before the flowers mature.

___ 13. Control by burning is effective for controlling annual plants but is undesirable from an environmental standpoint.

___ 14. Burning has a detrimental effect on the nutrients in the soil.

___ 15. Mulching excludes the light from plants, thus reducing photosynthesis.

C34. Associate herbicide uses and classifications.

Classifications and Uses of Herbicides. Herbicides are grouped on the basis of use into selectives and nonselectives and on the basis of mode of action into contact, translocated, and sterilant chemicals.

Selective. These herbicides kill certain weed species without seriously injuring the desirable plants among which they are growing. Those that kill crabgrass or dandelions in a grass sod are examples. Certain herbicides kill broad-leaved weeds and not grasses and vice versa.

Nonselectives. These herbicides kill vegetation with little discrimination. Certain species, however, are resistant and some escape. Resistant species are physiologically resistant to the chemical; some plants that escape are perennials that have part of their root system below treated layers of soil; others are annuals and shallow-rooted perennials that reinfest an area after the chemical has leached below the surface layer.

Contact. Herbicides in this class kill the tissues that are wetted with the spray. Whether the plant dies or recovers depends on whether it has a protected growing point. Perennials usually have underground buds that will regrow.

Contact herbicides include aromatic solvents and herbicidal oils. The aromatic solvents are also called solvent naphthas or petroleum naphthas. They include a variety of petroleum and coal distillates that can be used in heavy concentrations for aquatic-weed control. Kerosene, especially as sold in the eastern United States, mineral spirits, tractor distillate, low-grade diesel oil, and similar aliphatic materials do not control submersed weeds. The most effective products are those with a flash point above 80° F. (26.88° C.), distillation between 278° F. (137.76° C.) and 428° F. (221.76° C.), and an aramatic content of at least 85 percent. These solvents are highly flammable and irritating to the skin, eyes, and respiratory tissues. Livestock tend to avoid drinking treated water. Vegetation is not harmed when irrigated with treated water.

Aromatic solvents are deadly to fish. They are used in irrigation and drainage ditches, especially in short ditches (6 to 8 miles or less) with even sides and bottoms and with flows of 1 to 70 c.f.s.

Herbicidal oils are used as vegetation topkillers, as solvents in the formulation of herbicides, and as carriers for herbicidal chemicals. Oils that kill by contact should not be used as solvents or carriers of translocated herbicides, since a quick kill of the conducting tissue prevents translocation of the chemical.

Oils vary widely in their composition, value for herbicides, and flammability. Generally, the toxicity to plants is greater with increased content of aromatics. Aside from composition, the value for herbicides is influenced by some physical properties. If the boiling point is low, the oil may evaporate too rapidly; if too high, it does not penetrate plant tissues. The viscosity, or flowing quality, should permit use in cool weather. Specific gravity is important in aquatic-weed control. The flammability is indicated by the flash point; the lower the temperature at which an oil-vapor-air mixture ignites, the greater the danger of explosion.

Oil sprays wet leaf surfaces and penetrate waxy leaf surfaces more effectively than water sprays, are less easily washed off the plant, and evaporate more slowly under high temperatures. The effect of oils on perennials is temporary. Oils are used for a quick kill of topgrowth—a chemical substitute for mowing. They penetrate the leaves of nongrass plants, but kill grasses by creeping down the stem to the crowns and roots. Repeated treatments are necessary where seasons are long and rainfall is high. The cost depends on distance from source of supply. If relatively nontoxic, large volumes are necessary especially for oil-tolerant species, and aerial applications are impractical. Some of the disadvantages of the oils used alone can be overcome by fortifying them with phenol compounds or using them in conjunction with soil sterilants. The necessary volume can be reduced, the toxicity to tolerant weeds can be increased, a wider range of oils can be used, and the initial kill can be hastened, but the cost is raised.

The fortified oil sprays in low volume are effective on small weeds. When plants, especially grasses, are tall enough to protect their crowns, larger spray volumes are required. Emulsions provide larger volume although they do not increase toxicity to plants. The oil content can be varied 10 percent for easy-to-kill species and up to 25 percent for hard-to-kill species. Frequently, a fortified oil emulsion is more economical than a straight oil emulsion. Oils used as solvents or carriers may or may not be toxic to plants.

The fortified oil emulsions are well suited for killing all vegetation on roadsides, ditchbanks, and similar places and for spot treatments of shallow-rooted perennials. The staining that may result from oils carrying the dinitros when used on sidewalks and driveways is objectionable. Weed oils are preferred for such use and for oil-tolerant weeds.

As a class, oils are insoluble in water; when mixed with water in the presence of a surfactant, they form an emulsion. The common emulsion has oil dispersed in water; an invert emulsion is the reverse-water is dispersed in the oil. The fortifying chemical is dissolved in either the water or the oil or both.

Translocated. These chemicals are absorbed by the leaves and stems or by the roots, and move through the vascular system to leaves, buds, and root tips. When absorbed by the leaves and stems, the chemical is commonly moved with the food materials that were manufactured in the leaves and stems. When absorbed by the roots, the chemical moves in the water-conducting tissue. The growth-regulator type of translocated herbicide is a synthetic compound that behaves like a plant hormone. It accumulates mostly in areas of rapidly dividing cells upsetting the normal metabolism of the plant and causing death of the cells. Foliar applications of translocated herbicides are of great practical value, because small amounts are effective and they can be applied in small volumes of water or oil.

The foliage-applied nonselectives are used primarily to kill weeds on land later to be cropped; but they also are useful on land where long residuals are not required, where quick kills are needed, and where weeds have survived or escaped treatment with a long-lasting soil sterilant. Some of the selectives, like the phenoxy compounds, remove broad-leaved weeds from grass sods, while others, like dalapon, control grasses without severe injury to most broad-leaved plants. These herbicides are used where the killing of vegetation for long periods is undesirable.

Soil sterilant. This herbicide makes a soil incapable of supporting higher plant life, but it does not necessarily kill all life in the soil, such as fungi, bacteria, and other micro-organisms. Its toxic effects may remain for only a short time or for years. Residual toxicity depends on: (1) the chemical and its rate of decomposition or leaching, (2) the colloidal and chemical content of the soil, (3) species tolerance, and (4) rate of application.

Herbicides vary in their rate of disappearance from the soil because of volatility, susceptability to decomposition by soil micro-organisms, and solubility. For example, some of the carbamates are volatile at high temperatures and rapidly lose their toxic effect during the summer months. Certain soil micro-organisms effectively decompose 2,4–D. Amitrole is soluble in water and readily leached.

Some herbicides are readily absorbed by mineral and organic colloids and rendered unavailable or made slowly available for plant absorption. The fertility and pH of a soil are also influencing factors in the persistence or availability of toxic amounts of certain chemicals. For example, monuron and diuron are absorbed on clay colloid particles so that leaching is difficult. Sodium chlorate is more easily absorbed by plants growing in soil low in nitrates.

Plant species vary widely in tolerance to soil sterilants, but heavy rates of application generally last longer than light rates.

When present in the soil, sterilants prevent the growth of green plants. These chemicals are used in storage areas, lumberyards, and parking lots; on tennis courts, under pipelines, and transformer cages; under guardrails and surrounding signposts on highways and lights on runways; near fire hydrants, trestles, and bridges; on utility rights-of-way; on gravel blanket areas; around buildings, utility poles, and tank farms; along fence rows; for firebreaks; and in similar areas where any plant growth is undesirable. There are two major problems in maintaining bare ground: (1) no herbicide kills all species at reasonable rates of application and (2) reinfestation results from weed seeds in the soil after the herbicide has been leached below the surface. Meet these problems by using a combination of chemicals effective against the weed species to be killed and by repeated applications of the proper herbicide to kill seedlings.

The arsenicals are among the cheapest herbicides, but they must be handled carefully. Two groups of arsenicals are used for killing weeds; the inorganic and the organic.

The inorganic arsenicals include sodium arsenite, lead arsenate, and calcium arsenate. They are all highly poisonous to humans and other animals if swallowed. Their effectiveness for weed control depends on their arsenic content.

The organic arsenicals include disodium methylarsonate and amine methylarsonate. Both compounds are considerably less toxic than the inorganic arsenicals to humans and livestock, but they are harmful if swallowed. Both are applied postemergence for the control of crabgrass in turf.

Exercise (C34):

1. Match the herbicide classifications in column B below with the statements pertaining to the uses of herbicides in column A.

Column A

___ a. Kill certain weed species without seriously injuring the desirable plants among which they are growing.
___ b. Kill tissues wetted with the spray.
___ c. Makes soil incapable of supporting higher plant life.
___ d. These chemicals are absorbed by the leaves and stems or by the roots, and move through the vascular system to leaves, buds, and root tips.
___ e. These herbicides kill vegetation with little discrimination.

Column B

1. Contact.
2. Soil. Sterilant.
3. Selective.
4. Translocated.
5. Nonselective.

C35. Identify as correct or incorrect given statements concerning the chemical control of grasses and herbaceous broadleaf plants in specific areas; amend any that are incorrect.

Chemical Control of Grasses and Herbaceous Broadleaf Plants in Specific Areas. There are specific areas on and adjacent to Air Force installations where partial or complete vegetation control is required. Some of these areas are in and around highways, roadsides, utility lines, and railroads. In addition, weed control must be effective in turf areas, such as lawns, athletic fields, golf grounds, parade grounds, etc.

Paved highways. Vegetation that encroaches from the edges of asphalt pavement or grows up through cracks and holes causes premature breakdown of the pavements. You can control this type of vegetation with presurface and post-surface application of herbicides. Shoulders immediately adjacent to the trafficway, medians separating divided highways, and islands at highway intersections are often surfaced with asphalt. On such areas, apply the herbicide to the gravel base just before it is "shot" with asphalt. A standard highway watering truck can be adapted for this use by equipping it with a loading pump to circulate the spray material and with standard asphalt nozzles that deliver a fan spray.

Several herbicides prevent the emergence of plants through the pavement, but they vary in cost and in injury to vegetation adjacent to the paving. The plant growth on the unpaved area, particularly on fill slopes, may be desirable to prevent erosion. The following products control vegetation at the accompanying rates per foot-mile. (Rates per foot-mile × 8.25 = rate per acre.)

Chlorate-borate, 200 pounds (25 percent sodium chlorate)
Dalapon, 10 pounds
Dalapon-silvex, 2.5 gallons (4 lb. dalapon + 1/2 lb. silvex per gal.)
Diuron, 5 pounds
Erbon, 5 gallons (4 lb. per gal.)
Monuron, 5 pounds
Monuron, TCA, 0.9 gallon (3 lb. per gal.)
TCA, 25 pounds

Postpaving treatments are necessary later to prevent encroachment from unpaved areas and to control any vegetation growing up through cracks in old pavements. Use repeated spray treatments with dalapon-silvex mixture or use dalapon on grasses and 2,4–D or amitrole on broad-leaved weeds.

CAUTION: Erbon, monuron, and chlorate-borate mixture can injure vegetation some distance from the edge of the pavements, and monuron, diuron, and monuron TCA can injure trees adjacent to the treated area.

Roadsides. Herbicides are useful in the maintenance of roadsides if they are properly applied. The greatest dangers come from drift, runoff, improper application and leaching to roots of desirable species under the treated area.

Before spraying, make a survey of the area, spotting any slopes subject to erosion, the location of desirable vegetation, and the density and height of brush.

CAUTION: Drift hazards are greatest when growth-regulating herbicides, such as2,4–D, 2,4,5–T, and silvex, or contact herbicides are used as sprays, but damage often results from careless application. Drift occurs not only with volatile herbicides, such as the esters of 2,4–D and 2,4,5–T, but also with any spray that has been atomized into a mist by high pressure and a small nozzle opening. The volume of spray per unit area also influences drift. Where there are adjacent susceptible plants, use at least 10 gallons per acre and move the sprayer at slow speed.

It is especially important to reduce mist when you spray with a handgun. Operate at low pressure (30 to 60 psi). Direct spray downward as much as possible, and do not spray when it is windy. When you are treating edges of roads, spray from the outside toward the pavement.

Runoff is an important hazard on slopes, bare ground, and pavements. Cutback asphalt applied with a soil sterilant helps to hold the chemical in place. Use 39 gallons per 1,000 square feet, or 1,700 gallons per acre or use a light covering of road oil. If there has been an excavation, add a layer of crushed rock. Trees and shrubs some distance from soil treated with soil sterilants may be killed if their roots extend below this area.

Utility lines. Make two complete sprayings of all transmission lines at 2-year intervals—the first to kill as much growth as possible and the second to kill escapes and resistant species. Spray only those species that grow tall enough to interfere with the lines. If the plants are over 6 feet tall, cut and spray the stump.

Fenuron pellets at 12½ pounds per acre, active ingredient, kill alder, blackberries and sumac; elderberry, elm, hawthorn, maple, or willow are not killed, but all species are defoliated.

TCA and dalapon are moderately effective on conifers.

Foliage sprays of 2,4,5-T at 2½ pounds per 100 gallons of water control many species of hardwood brush throughout the season. They are most effective when applied soon after leaves are fully expanded and when the plants are growing actively. Esters of 2,4-D plus 2,4,5-T in equal proportions (brush killer) kill alder, smooth and staghorn sumac, and willow.

Railroads. There are three areas on railways on which weed control is necessary: the ballast, the roadbed, and the right-of-way. The ballast is a strip 12 to 16 feet wide, made up of coarse material, such as cinders or gravel, that should be kept free from weeds. Because the ballast is so porous, it does not retain chemicals well. Insoluble herbicides, those absorbed through leaves, and contact herbicides are most suitable.

The roadbed (berm) beyond the ballast requires weed control, but elimination of vegetation increases erosion. The rest of the area to the right-of-way fence is similar to roadsides. If control is effected during the first 2 years by heavy rates of application, it can be maintained with reduced rates thereafter. The effectiveness of some soil sterilants like diuron and simazine may not show up until the second or third year of use, especially in dry areas or with deep-rooted weeds.

Apply 5 to 8 gallons of dalapon-silvex mixture, in 150 to 300 gallons water per acre-mile on ballast and berm areas, or 5 to 6 quarts of DNAP and 300 gallons of diesel oil per mile on roadbed. For heavy growth, add 300 gallons of water.

Turf. Weeds in lawns, athletic fields, golf grounds, parade grounds, the turf portions of roadsides and railroad rights-of-way, and similar areas are controlled by good maintenance practices supplemented with chemical herbicides. It is important to prevent the encroachment of weeds by maintaining competition from vigorously growing turf grasses. The principal factors in maintenance are soil, grass, water, mowing, and pests.

Both the physical and chemical properties of the soil are important. Adequate organic-matter content, drainage, and aeration are as essential as proper fertility. The selection of the grass or grasses to be seeded is also important. Each type has its requirements for optimum adaptation. Water not only keeps plants from wilting, it is itself a nutrient and it acts as a solvent and carrier of nutrients and food. The frequency and height of mowing are important. The height is determined by the kind of grass, and the frequency depends on rate of growth. Pests include insects diseases and weeds. These often require treatment beyond good maintenance practices. Insecticides, fungicides, and herbicides are supplementary controls.

Chemicals are useful for killing weeds (1) in preparation for seeding, (2) where weeds have become established in disturbance areas, or (3) where, for other reasons, there is an incomplete cover of desirable grasses.

Turf weeds comprise (1) broadleaved species that can be killed with one group of herbicides without seriously injuring turf grasses and (2) undesirable grasses that can be controlled by a second group of chemicals. The morphological and physiological differences between broadleaf weeds (dicotyledons) and grasses (monocotyledons) make selective control possible. Where weedy grasses are to be removed from turf grasses, selectivity is accomplished usually if the weed is an annual and the turf grass is a perennial.

NOTE: Specific chemicals and applications for most types of weeds are provided in Appendix A of the supplement to Volumes 4, 5, 6, and 7.

Exercises (C35):

Identify the following statements as being correct (C) or incorrect (I). Explain why the incorrect statements are not true.

___ 1. Vegetation along the edges and in the crack of asphalt pavement are very difficult to control.

___ 2. Presurface treatment may be done with a standard highway watering truck.

___ 3. Care must be taken during post-surface treatment to prevent injury to plants adjacent to the roadway.

___ 4. When treating roadsides, proper application will insure safety for desirable plants.

___ 5. Spraying when windy will guarantee best results.

___ 6. When treating utility lines, all species must be treated.

___ 7. Utility lines should be treated every 2 years.

___ 8. Foilage sprays are most effective when applied soon after leaves are fully expanded and when the plants are growing actively.

___ 9. Railroads require treatments in three areas; the ballast, the roadbed, and the right-of-way.

___ 10. The railroad treatment for roadbed should kill all vegetation.

___ 11. Lawns, athletic fields, parade grounds, and golf courses can be controlled primarily by good maintenance practices.

___ 12. In lawns, all undesirable plants can be controlled by the application of one herbicide.

C36. Complete given statements pertaining to herbicide precautions.

Precautions for Using Herbicides. There are several actions you must take before you apply herbicides:

(1) Identify the weeds you want to control.

(2) Select the right herbicide to control these weeds without harm to desirable plants nearby.

(3) Read the herbicide label.

(4) Mix the chemical according to mixing directions. Do not use more than recommended amounts.

(5) Plan to apply the materials when and how the directions indicate.

(6) Select the proper equipment.

(7) Study the safety precautions on the label.

Herbicide labels. Labels on the herbicide container are written with great care to state only facts. Recommendations on labels for materials sold interstate must be registered with the Environmental Protection Agency before the label can be authorized. Always read the label. It tells, first, what the herbicide is. For instance, 2,4–D is sold as a sodium or amine salt or a volatile or low-volatile ester. Recommendations differ for various herbicides and for various formulations of the same basic chemical.

The label tells the amount of acid equivalent, phenol equivalent, or active ingredient in the product. This information helps you compare the concentrations in various formulations. The label also makes recommendations for use and gives rates and time of application. Certain warnings are stated when necessary to protect the operator from poison or irritation by the chemical and to protect susceptible plants from injury.

Protection of desirable plants. Certain precautions are necessary to prevent damage to adjacent valuable plants. This damage may result from drift, washing or leaching:

a. Drift hazards. Remember that drift hazards are
greatest when herbicides that affect the leaves of plants 6
are used. These may be of the growth regulating type or 5
of the contact type. Danger is least when dry
applications are made of nonvolatile herbicides. Keep 3
in mind that drift occurs not only with volatile herbicides but also from a spray that has been atomized into a mist.

b. Washing. Washing is an important hazard on slopes, bare ground, and pavements. The herbicides may be carried by surface runoff to valuable plants downslope. Do not drain or flush equipment where runoff to desirable plants may occur.

c. Leaching. Leaching moves chemicals downward through the soil. If they are readily absorbed by roots, plants whose roots extend under the treated area are likely to be injured. Avoid treating such areas with soil sterilants. Do not drain or flush equipment where leaching to the roots of desirable plants may occur.

Protection of game and fish. Most herbicides are less dangerous than insecticides to wildlife. There are a few, however, such as the arsenicals and dinitros, that can poison animals. Most injury results from overdoses and spillage. Indiscriminate spraying and spraying that results in defoliation of vegetation can destroy cover, but herbicides can also be useful in management. Openings in wooded areas, such as the clearing for utility company rights-of-way and spraying of hardwoods in stands of pine can be beneficial to wildlife.

A few herbicides are very toxic to fish, but many can be used safely for the control of aquatic weeds. The control of submerged weeds in ponds or streams can be beneficial to fish population. Safe amounts of herbicides, expressed in parts of the chemical per million parts of water, vary widely with the age, size, and species of fish.

Whenever a proposed spraying program might endanger game and fish, consult the Federal or State Fish and Wildlife Service for advice.

Exercises (C36):

Complete the following statements pertaining to precautions to be observed for using herbicides.

1. Before applying herbicides you should ______ the weeds you want to kill; select the right ______ to control the weeds without harm to ______ plants; and mix chemicals according to ______ ______.
2. Labels on herbicides containers are written with great care and state only ______.
3. Recommendations on labels for materials sold interstate must be registered with the ______ ______ ______ before the label can be ______.
4. Drift hazards are greatest when herbicides that affect ______ of plants are used.

5. Danger is least when ______ applications are made of ______ herbicides.
6. Drift occurs with ______ herbicides whether they are volatile or not.
7. Washing is an important hazard on ______, ______ ______ and ______ .
8. Leaching moves chemicals ______ through the soil.
9. Most herbicides are less hazardous than insecticides to ______ .
10. Most injuries to wildlife are the result of ______ and ______ .

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ANSWERS FOR EXERCISES

CHAPTER I

C01 - 1. Buildings; food and property.
2. Fields, grain elevators, processing mills, trucks and trains, and home.
3. Feces and urine; feeding; human consumption; food.
4. killing.
5. Concrete, brick, wood, and metal.
6. Spontaneous combustion; nesting.
7. Rat flea.
8. Teeth and gums; bite of the rat.
9. House mouse; bite; mouse.
10. Worldwide.

C02 - 1. (1) Longer than head plus body.
(2) Shorter than head plus body.
(3) Slender.
(4) Heavy, thick.
(5) Large.
(6) Small.
(7) Large.
(8) Small.
(9) Pointed.
(10) Blunt.
(12). Small.
(14) Small.
2. a. House mouse.
b. Norway rat.
c. Roof rat.

C03 - 1. Short, rapidly.
2. Die, killed.
3. Body, unattended.
4. Eyes, ears, hairless, legs.
5. A week.
6. Twelve, 14.
7. Three.
8. Eyes open.

C04 - 1. Correct.
2. Incorrect. Change "father" to "mother."
3. Incorrect. Change "dawn" to "dusk."
4. Correct.
5. Correct.
6. Incorrect. Change "4" to "2."
7. Correct.
8. Incorrect. Change "noisy" to "quiet."
9. Correct.
10. Correct.

C05 - 1. Species, amount, food, dangers.
2. Sunset each.
3. Steady, nibblers.
4. Meats, grain, cooked eggs, potatoes.
5. Environment.

C06 - 1. C.
2. C.
3. C.
4. I; droppings may be a key.
5. C.
6. C.
7. C.
8. C.

C07 - 1. Number, rats.
2. Unsanitary, refuse, disposal.
3. Cans, approved, garbage, rubbish.
4. Twelve, 18.
5. Inspections, rodent.

C08 - 1. Twenty-six, 1/4-inch, neat, ratproofing.
2. Twenty-four, ground.
3. Snap, mice.
4. Fruits, vegetables.
5. Oils.
6. Poisoning.
7. Water, rodenticide.
8. Strong taste, odor.
9. Man, domestic animals.
10. Supplementary, untrained.
11. Occupied buildings.

C09 - 1. a, d, and e are true statements.
2. b. Change "deer or white-footed" to "rice and cotton rats"
c. Change "rice and cotton rats" to "deer or white-footed mice"

C10 - 1. d.
2. f
3. b
4. a
5. e
6. c

C11 - 1. Damage, runways, tracks.
2. Trapping.
3. Trapping poisoning.
4. Rolled oats, nutmeats.
5. Zinc, strychnine.
6. Fruits, vegetables, grains, seeds.
7. Grass, litter.
8. Walls, banks, tree.

C12 - 1. a.Ground squirrel, *Citellus*.
b. Groundhog, woodchuck, marmot, *Marmota*.
c. Prairie dog, *Cynomys*.

C13 - 1. a, b, c, f, g, h are true.
2. d. Change "dry" to "damp."
e. Change "more" to "less."

C14 - 1. Plague.
2. Airfields, training.
3. Digging claws.
4. Roots, tubers, bulbs.
5. Food.
6. Baiting, trapping, gassing.
7. Seal, escape.
8. Not.
9. Summer, fall.

C15 - 1. 1, 3, 4, 5, and 7 are true.

C16 - 1. Humidity; soil.
2. Lawns; golf courses; seed beds.
3. Pests; diseases.

C17 - 1. b, c, d, f, g, and h are true.
2. a. Insert the word "not" before rodent.
e. Change mound to ridges.

C18 - 1. Their presence is evident from their digging.
2. Make small breaks in a number of runs and check them several times during the day or night.

C19 - 1. Food; trapping, drowning, or gassing; repellents.
2. Insecticides.
3. Unnatural.
4. Food.
5. Gripping.
6. Runways.

7. Cost.
8. Lye and naphthalene.
9. Woven wire or concrete.
10. Strychnine.
11. Choker-loop trap, scissors-jaw trap, and diamond-jaw trap.
12. Harpoon.
13. Soil.

C20 - 1. False. Change "family" to "order."
2. False. Nearly worldwide.
3. True.
4. True.
5. True.
6. False. They are more streamlined and have smoother fur.
7. False. Change "usually" to "rarely."
8. True.
9. True.
10. False. Throughout the year with peaks in the spring and fall.
11. False. Some forms are aquatic.
12. True.

C21 - 1. Foxes.
2. Rabies.
3. Damage.
4. Traps.
5. State health authorities.

C22 - 1. False. Before you use a control measure that could injure the animals, get approval through the chain of command.
2. True.
3. True.
3. True.
4. False. They carry ectoparasites.
5. True.
6. True.

C23 - 1. They carry disease; they serve as hosts to parasites that attack people; they create an overwhelming ammonia odor; they make noise.
2. They control insects.

C24 - 1. True.
2. False. At dusk.
3. True.
4. False. It is difficult.
5. True.
6. False. It does not give lasting control.
7. False. They are the only ones.
8. False. Most eat insects. Only vampire bats feed on blood.
9. True.
10. False. New bats are attracted by this odor.
11. True.

C25 - 1. (1) h.
(2) d.
(3) b.
(4) f.
(5) c.
(6) g.

C25a - 1. True.
C25a - 2. You usually will be concerned with birds that roost in large flocks.
C25a - 4. True.
C25a - 5. True.
C25a - 6. Species that typically roost on or in manmade structures are of particular concern to you.
C25a - 7. Pigeons roost on ledges, rafters, and other structures that give them protection from harsh weather and predators.
C25a - 8. True.
C25a - 9. Food and feeding habits of birds vary with species, season, and availability of food items.
C25a - 10. True.
C25a - 11. Red-winged blackbirds' diet consists largely of insects during the nesting season.
C25a - 12. True.
C25a - 13. Feeding flocks of birds may pose a bird/aircraft strike hazard.
C25a - 14. True.
C25a - 15. Birds species differ in their ability to learn.
C25a - 16. The learning is the declining response to a simple stimulus with no punishment associated with that stimulus.
C25a - 17. True.

C25b - 1. a. Primaries.
b. Side.
c. Crown.
d. Forehead.
e. Lore.
f. Throat.
g. Breat.
h. Secondaries.
i. Flank.
j. Crissum.
k. Rump.
l. Bank.
m. Nape.
n. Crown.
o. Forehead.
p. Chin.
q. Throat.
r. Breast.
s. Belly.

C25b - 2. Primary and secondary feathers make up the flight feathers.
C25b - 3. Acts as a brake to slow flight.
C25b - 4. Tearing the food apart.
C25b - 5. (1) c.
(2) a.
(3) e.
(4) b.
(5) f.
(6) d.

C25c - 1. (1) a.
(2) c.
(3) b.
(4) c.
(5) a.
(6) a.

C25c - 2. Psittacosis.
C25c - 3. A protective mask must be worn; it should be of the disposable type.
C25c - 4. Incineration.
C25c - 5. Loss of lives and destruction of aircraft.
C25c - 6. Engines sitting idle for repairs.
C25c - 7. House sparrows and starlings.

C25d - 1. (1) b.
(2) e.
(3) c.
(4) a.
(5) c.
(6) b.
(7) b, d.

C25d - 2. Habitat modification.
C25d - 3. Obtain an appropriate permit.
C25d - 4. Netting or crisscrossed wire.
C25d - 5. Sharp spikes.
C25d - 6. Transient; roosting; loafing.
C25d - 7. 100 yards.
C25d - 8. It persuades the birds that they are not in danger, and they will ignore the tape.
C25d - 9 It must have a no-choke or an open-choke barrel.
C25d - 10. Leather gloves, ear protectors, and goggles.
C25d - 11. Four Explosive B placards.
C25d - 12. A 10-pound B and C type fire extinguisher must be available and you should have two on hand.

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C25d -13. Recorded distress or alarm calls.
C25d -14. They have a low-operating cost.
C25d -15. Cracked corn, peanut butter, or apples.
C25d -16. At least 40 miles.
C25d -17. With an indigo red dye.
C25d -18. Verbail pole trap and the Bal-Chatri trap; the Verbail trap snares birds of prey by the feet when they perch atop a pole. The Bal-Chatri trap uses nooses to entangle the feet of raptors that are attracted by live bait in a cage.
C25d -19. The U.S. Fish and Wildlife Service.

C25e - 1. When the problem is just beginning to develop or even before it begins.
C25e - 2. Past experience and good documentation should be employed.
C25e - 3. The location in which birds carry out their activities could cause a problem; therefore, you must determine specifically what the birds are doing, where they are doing it, and when they are doing it.
C25e - 4. Food, water, a place to nest, and a place to escape their enemies or avoid harsh weather will attract birds to the airdrome environment. They may be eliminated by habitat manipulation.
C25e - 5. To maintain historical data on pest/hazardous bird species. It will help you in identification and evaluation of pest problems so that you may decide if active control is needed. It also is useful in future surveys. You also should record weather conditions as they affect bird activities.

CHAPTER 2

C26 - 1. Their ability to thrive in cultivated land.
2. (1) Underground roots or stems. This characteristic permits weeds to persist even if seed production is prevented. Cultivation spreads pieces of roots to other areas.
(2) Abundant seed production. Weeds produce thousands of seeds that can live from 10 to 50 years.
(3) Rapid growth. Seeds form before control measures can be taken.
(4) Competitive ability. Weeds can compete more successfully than desired plants for light and nutrients.
(5) Unpalatability to livestock. Weeds can reproduce and spread without being hindered by animals.

C27 - 1. a. 5
b. 2
c. 3
d. 7
e. 10
f. 1
g. 6
h. 8
i. 4
j. 9

C28 - 1. I. They separate from the soil and are no longer dependent on the soil.
2. C.
3. C.
4. I. During normal growth these plants will extend above the water surface.

C29 - 1. Mechanical.
2. Size; terrain; equipment and operators.
3. Canals and drainage; chain; tractors.
4. Rooted; emersed.
5. Back; opposite direction.
6. Raking.
7. Weeding forks; buckets.
8. Mud; capacity.
9. Complete drainage.
10. Searing, burn.
11. Sides.
12. Weed saws; cutters; emersed.
13. Chemicals; sprays or granules.
14. Porous; chemicals; dragged; dissolved.
15. Fish and snails; eliminate.

C30 - 1. C.
2. C.
3. I. Vines climb on other plants or sprawl on the ground.
4. C.
5. I. Some plants have both.
6. C.
7. I. Considerable labor is required.
8. I. Used where hazards of poisoning are not important.
9. C.
10. C.

C31 - 1. T.
2. T.
3. T.
4. F.
5. F.
6. F.
7. T.
8. F.

C32 - 1. Wide leaves; netted.
2. Clusters; nodes; branches.
3. Dicots; germination.
4. Deep and strong.
5. Tap; lateral.

C33 - 1. C.
2. I.
3. C.
4. C.
5. I.
6. C.
7. C.
8. I.
9. C.
10. C.
11. I.
12. C.
13. C.
14. I.
15. C.

AUGAFS, AL (824964) 500

U.S. GOVERNMENT PRINTING OFFICE: 1982—546-034/692

STOP- 1. MATCH ANSWER SHEET TO THIS EXERCISE NUMBER.
2. USE NUMBER 2 PENCIL ONLY.

EXTENSION COURSE INSTITUTE
VOLUME REVIEW EXERCISE

56650 07 22

Collection, Identification, and Control of Important Vertebrate and Vegetative Pests

Carefully read the following:

DO's:

1. Check the "course," "volume," and "form" numbers from the answer sheet address tab against the "VRE answer sheet identification number" in the righthand column of the shipping list. If numbers do not match, return the answer sheet and the shipping list to ECI immediately with a note of explanation.
2. Note that item numbers on answer sheet are sequential in each column.
3. Use a medium sharp #2 black lead pencil for marking answer sheet.
4. Write the correct answer in the margin at the left of the item. (When you review for the course examination, you can cover *your* answers with a strip of paper and then check your review answers against your original choices.) After you are sure of your answers, transfer them to the answer sheet. If you *have* to change an answer on the answer sheet, be sure that the erasure is complete. Use a clean eraser. But try to avoid any erasure on the answer sheet if at all possible.
5. Take action to return entire answer sheet to ECI.
6. Keep Volume Review Exercise booklet for review and reference.
7. If *mandatorily* enrolled student, process questions or comments through your unit trainer or OJT supervisor. If *voluntarily* enrolled student, send questions or comments to ECI on ECI Form 17.

DON'Ts:

1. Don't use answer sheets other than one furnished specifically for each review exercise.
2. Don't mark on the answer sheet except to fill in marking blocks. Double marks or excessive markings which overflow marking blocks will register as errors.
3. Don't fold, spindle, staple, tape, or mutilate the answer sheet.
4. Don't use ink or any marking other than a #2 black lead pencil.

NOTE: **NUMBERED LEARNING OBJECTIVE REFERENCES ARE USED ON THE VOLUME REVIEW EXERCISE.** In parenthesis after each item number on the VRE is the *Learning Objective Number* where the answer to that item can be located. When answering the items on the VRE, refer to the *Learning Objectives* indicated by these *Numbers*. The VRE results will be sent to you on a postcard which will list the *actual* VRE *items you missed*. Go to the VRE booklet and locate the *Learning Objective Numbers* for the items missed. Go to the text and carefully review the areas covered by these references. Review the entire VRE again before you take the closed-book Course Examination.

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MULTIPLE CHOICE

Note to Student: Consider all choices carefully and select the *best* answer to each question.

1. (C01) Rats destroy property by

   a. gnawing through wood, brick, and concrete.
   b. contamination.
   c. killing domestic animals.
   d. doing all of the above.

2. (C01) Which of the following diseases, caused by rodent contamination, is a food poisoning disease that causes diarrhea and dysentry?

   a. Plague.
   b. Salmonellosis.
   c. Rickettsialpox.
   d. Murine typhus fever.

3. (C02) Which one of the following is the most common and largest of the domestic rats?

   a. Roof.
   b. House.
   c. Norway.
   d. Russian.

4. (C03) The gestation period for murine rodents is

   a. 3 weeks.
   b. 6 weeks.
   c. 12 weeks.
   d. 24 weeks.

5. (C03) Newborn rats and mice open their eyes at about how many days of age?

   a. 7.
   b. 14.
   c. 21.
   d. 28.

6. (C04) When rats are exposed to a new type of food, what is their first reaction?

   a. Avoid the new food.
   b. Eat only a token amount.
   c. Eat a small amount.
   d. Eat until full.

7. (C04) Rats prefer to climb or run along paths that are

   a. horizontal.
   b. vertical.
   c. gently sloping.
   d. open and exposed.

8. (C04) Rats can make a standing high jump of approximately how many feet?

   a. 2.
   b. 3.
   c. 5.
   d. 7.

9. (C05) Which of the following foods is preferred by Norway rats?

   a. Onions.
   b. Celery.
   c. Oatmeal.
   d. Highly spiced foods.

10. (C05) Which is the best statement concerning the feeding habits of murine rodents?

    a. All three species have regular eating habits.
    b. All three species have irregular eating habits.
    c. Rats usually begin searching for food after midnight.
    d. Mice are steady eaters, rats are nibblers.

11. (C06) Generally, finding rat droppings of several sizes indicates

a. more than one type of rat is infesting the area.
b. a heavy infestation of rats.
c. the type of food rats have been eating.
d. several ages of rats are present.

12. (C06) Where are Norway rat runs normally found?

a. Anywhere.
b. On the roof.
c. In the grass.
d. Near the floor.

13. (C07) What is the *primary* factor influencing rat infestations?

a. Rubbish in the area.
b. Infrequent refuse collection.
c. Amount of food and harborage available.
d. Temperature and humidity range.

14. (C07) Sanitation for the control of rats and mice involves storage of foodstuffs how many inches off the floor?

a. 2 to 3.
b. 4 to 6.
c. 12 to 18.
d. 24 to 36.

15. (C08) What size mesh hardware cloth is suitable for rodentproofing?

a. 1/8-inch.
b. 1/4-inch.
c. 1/2-inch.
d. 3/4-inch.

16. (C08) Which type of trap is most efficient for killing rodents?

a. Steel.
b. Box.
c. Cage.
d. Snap.

17. (C08) What type of bait does the Norway rat favor?

a. Bacon and grains.
b. Cheese and eggs.
c. Potatoes and nuts.
d. Meat and fish.

18. (C09) The overall importance of field mice and rats on a military installation is *primarily*

a. economic.
b. morale.
c. nuisance.
d. medical.

19. (C10) What species of mice live *primarily* on the surface and may even live and travel about in trees?

a. Rice mice.
b. Pine mice.
c. Meadow mice.
d. White-footed mice.

20. (C10) Which rat is chiefly vegetarian, eating flowers, fruit, seed, and bark?

a. Rice.
b. Pine.
c. Wood.
d. Meadow.

21. (C11) When trapping meadow and pine mice, what should you use as bait?

a. Bacon or eggs.
b. Oatmeal or apples.
c. Syrup or molasses.
d. Pork or beef.

22. (C11) When baiting for field mice, where should you place the bait?

a. Near the trunk of trees.
b. In grass close to the trail.
c. About one-half inch below ground.
d. Directly on the floor of used trails.

23. (C12) Which of the following feral rodents are colonial and live in "towns"?

a. Woodchucks.
b. Groundhogs.
c. Prairie dogs.
d. Ground squirrels.

24. (C12) What is the *greatest* concern with feral rodents on a military installation?

a. Morale.
b. Medical.
c. Nuissance.
d. Economic.

25. (C13) To trap ground squirrels, what bait is best?

a. Apple.
b. Oatmeal.
c. Candy.
d. Peanut butter.

26. (C13) To control members of the squirrel family, the recommended dosage of poisoned grain bait is one tablespoonful of grain scattered over an area of how many square feet?

a. 1-2.
b. 5-10.
c. 20-25.
d. 50-100.

27. (C14) On what items do gophers feed?

a. Roots and bulbs.
b. Leaves and stems.
c. Cereals and clover.
d. Bark and foliage.

28. (C14) What is the *best* way to locate the main runway of a gopher?

a. Observing the mounds.
b. Using a probe.
c. Flushing with a water hose.
d. Observing the grasses above the runway.

29. (C15) All of the following are true rabbits, of the genus *Sylvilagus*, *except* the

a. jack rabbit.
b. cottontail.
c. marsh rabbit.
d. brush rabbit.

30. (C15) Which of the following characteristics is *not* true of hares and rabbits?

a. They are heavily furred, with long ears and elongated hindlegs.
b. They damage trees and erosion control plants.
c. They are carriers of spotted fever and tularemia.
d. They can be controlled by epizootics alone.

31. (C16) Upon what condition does the distribution of moles largely depend?

a. Food supply.
b. Water supply.
c. Atmospheric humidity.
d. Atmospheric temperature.

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32. (C16) Approximately how many yards can a mole travel through loose soil in a day?

a. 5.
b. 25.
c. 50.
d. 100.

33. (C17) Which of the mole's senses seems to be the *most* poorly developed?

a. Hearing.
b. Touch.
c. Sight.
d. Smell.

34. (C17) In proportion to its weight, how much food will a mole eat in a day?

a. 10 percent.
b. 25 percent.
c. 50 percent.
d. 100 percent.

35. (C18) What action will a mole take if an opening is made in its runway?

a. Tunnel around the breach.
b. Repair the breach.
c. Abandon the runway.
d. Ignore the breach.

36. (C19) When trapping moles, it is important for you to be aware of a mole's

a. feeding habits.
b. periods of inactivity.
c. unsuspecting nature.
d. sensitivity to an unnatural environment.

37. (C19) The method of eliminating moles that is universally applicable and satisfactory is

a. drowning.
b. trapping.
c. gassing.
d. baiting.

38. (C20) Shrews may be characterized as

a. quiet.
b. gentle.
c. playful.
d. belligerent.

39. (C20) The diet of shrews consists *primarily* of

a. grain.
b. roots.
c. animal food.
d. vegetables.

40. *(C21) Select the correct* statement concerning predatory animals.

a. They may be killed without prior approval of the command entomologist.
b. They are reservoirs for rabies.
c. They present *no* hazard to airfield equipment.
d. Predatory animals are controlled by natural extinction.

41. (C22) Who has overall responsibility for controlling domestic pets?

a. Owner.
b. Security police.
c. Entomology specialist.
d. Base hospital.

42. (C22) Ten military housing units will have approximately how many domestic animals?

a. 2.
b. 5.
c. 10.
d. 20.

43. (C23) In what way are bats considered beneficial to man?

a. They control other animal populations by transmitting diseases to them.
b. They consume huge numbers of insects.
c. Their excrement is a source of rich fertilizer.
d. They are valuable in medical research.

44. (C24) How can bats be controlled without killing them?

a. By creating loud noises at night.
b. By scattering cyanide pellets around roosting places.
c. By scattering napthalene flakes around roosting places.
d. By creating loud noises during the daytime.

45. (C24) Fumigation is undesirable for bat control because

a. some bats are immune to fumigants.
b. the bats leave when fumigation starts and return late.
c. bats should not be killed.
d. unrecoverable bats decompose and create an offensive odor.

46. (C25) If nesting sparrows leave corrosive droppings or holes in a building's screening, the problem is *best* defined as

a. bird damage.
b. a bird strike.
c. a bird hazard.
d. a bird nuisance.

47. (C25) When birds present a potential threat to health or safety, the condition is referred to as

a. bird management.
b. a bird hazard.
c. bird damage control.
d. pest birds.

48. (C37) Which of the following characteristics determines where a given bird species will nest, roost, or feed?

a. Cover.
b. Colony.
c. Habitat.
d. Territory.

49. (C37) The areas where birds roost during daylight hours are called

a. loafing areas.
b. feeding sites.
c. resting sites.
d. roosting areas.

50. (C37) Which of the following *most* accurately depicts the feeding habit of the bird species indicated?

a. Swallows, herbivorous and insectivorous.
b. Starlings, herbivorous and granivorous.
c. Gulls, omnivorous.
d. Hawks, omnivorous.

51. (C37) Birds that feed upon dead plants and animals are referred to as

a. scavengers.
b. granivores.
c. omnivores.
d. herbivore.

52. (C37) How do birds learn?

a. By observation, chance, and stimulus.
b. By trial and error, chance, and stimulus.
c. By practice, experience, and observation.
d. By practice, experience, and trial and error.

53. (C37) Habituation results in

a. birds learning that distress calls or noise makers represent no real danger.
b. birds reacting to the sight of dead birds by flying away.
c. birds learning that a shotgun blast can cause harm.
d. birds being frightened by distress calls.

54. (C38) The top of a bird's head is referred to as the

a. nape.
b. lore.
c. crown.
d. skull.

55. (C38) The inner flight feathers mainly responsible for the bird's lift are called

a. coverts.
b. primaries.
c. scapulars.
d. secondaries.

56. (C38) The covert feathers of the shoulder area of a bird are referred to as

a. primaries.
b. scapulars.
c. speculars.
d. secondaries.

57. (C38) The speculum of a duck's wing is part of the

a. secondary feathers.
b. primary feathers.
c. tail coverts.
d. scapulars.

58. (C38) Identify the pest birds that have long pointed wings, hooked bills and usually have square tails.

a. Gulls.
b. Pigeons.
c. House sparrow.
d. Common grackle.

59. (C38) Which of the following pest birds was introduced from Europe and is actually a small weaver finch?

a. House sparrow.
b. Rock dove.
c. Starling.
d. Sparrow.

60. (C39) Both histoplasmosis and psittacosis are commonly contacted

a. from bites of domestic rodents.
b. from bites from any insect vector.
c. by wading in contaminated ponds.
d. by inhalation of contaminated dust or particles.

61. (C39) One of the *most* serious diseases associated with birds is

a. malaria.
b. psittacosis.
c. encephalitis.
d. histoplasmosis.

62. (C39) At what phase of flight operations do almost half of all bird strike occur?

a. During enroute flight.
b. During take-off and landing.
c. During high altitude flight.
d. During engine warm-up and shutdown.

63. (C39) More than half of the bird strikes that result in aircraft loss are involved with which one of the following factors?

a. The aircraft wing.
b. Poor pilot avoidance.
c. Windscreen or canopy collisions.
d. Loss of rudder control.

64. (C40) What is the *best* solution to keep birds from feeding on insects that are exposed during airfield mowing operations, thereby causing a strike hazard?

a. Apply a suitable avicide.
b. Apply a suitable insecticide.
c. Mow grass at night or on weekends.
d. Mow grass only when clearance is given by base operations personnel.

65. (C40) Which of the following types of repulsion is *not* generally used on an airfield?

a. Tactile.
b. Taste/odor.
c. Behavior.
d. Auditory.

66. (C40) Denying birds access to an area where they can potentially cause problems *best* describes

a. altering the situation.
b. exclusion.
c. altering the concept.
d. repulsion.

67. (C40) What bird control technique are you using if y[illegible]educe the birds' habitat in the area near an airfield.

a. Exclusion.
b. Repulsion.
c. Alter the concept.
d. Alter the situation.

68. (C41) Before any bird problem can be effectively and efficiently controlled, it must first be

a. identified and documented.
b. identified and evaluated.
c. evaluated and described.
d. described and documented.

69. (C41) What is the *primary* reason you should determine whether birds observed are resident or transient?

a. Resident birds are protected by state law.
b. Migratory birds are protected by federal law.
c. Transient birds may soon leave the area on their own.
d. Transient birds are harder to repel than resident birds.

70. (C41) When should you begin a bird control program?

a. Before a bird strike occurs.
b. Before a roost is established.
c. After a seasonal pattern is established.
d. Before a seasonal pattern is established.

71. (C41) In an effective bird management program, a complete installation inspection should be conducted every

a. two weeks.
b. six weeks.
c. month.
d. year.

72. (C26) What is the *most* important growth characteristic of weeds?

a. Competitive ability.
b. Rapid growth ability.
c. Abundant seed production.
d. Ability to thrive in cultivated land.

73. (C27) What type of plant, propagated by seed only, requires two seasons to complete its reproduction cycle?

a. Annual.
b. Biennial.
c. Perennial.
d. Seminannual.

74. (C27) What type of weed with creeping roots or stems is generally considered to be the most noxious?

a. Annual.
b. Biennial.
c. Perennial.
d. Semiannual.

75. (C28) Emersed aquatic plants

a. use the bottom of a body of water for germination only.
b. float on the water surface.
c. are firmly rooted to the soil and will extend above the water surface.
d. complete their entire life cycle below the water surface.

76. (C28) To what group of aquatic plants do algae belong?

a. Emersed.
b. Floating.
c. Suspended.
d. Submersed.

77. (C29) What is the *most* popular aquatic weed control measure?

a. Chemical.
b. Biological.
c. Mechanical.
d. Natural extinction.

78. (C29) Which mechanical control measure is equally effective for all types of aquatic vegetation?

a. Dredging.
b. Chaining.
c. Burning.
d. Mowing.

79. (C30) Which of the following traits is *not* a characteristic of woody plants?

a. Root system is extensive.
b. Branches are relatively sturdy.
c. Only grow to about twelve feet in height.
d. Trunk is self supporting.

80. (C30) What is the *most* satisfactory chemical application method for controlling brush that is over 0.9 meters tall along roadsides?

a. Stump application.
b. Soil application.
c. Basal-bark application.
d. Foliage application.

81. (C31) What are cotyledons?

a. Grasses with fibrous root systems.
b. Tiny leaf-like structures that emerge from germinated seed.
c. The parallel venations of grass leaves.
d. Grasses that are perennial.

82. (C32) Which of the following is *not* a characteristic of herbaceous broadleaf plants?

a. The root system is relatively shallow and extensive.
b. The leaves are relatively wide with netted venation.
c. There are two leaf-like structures that appear upon germination.
d. There are clusters of leaves at the ends of branches.

83. (C32) What type of cotyledon are herbaceous broadleaf plants?

a. Dicotyledons.
b. Tricotlydons.
c. Monocotlydons.
d. Quadricotlydons.

84. (C33) What type of control is often the only method available for controlling weeds in inaccessible areas?

a. Mechanical.
b. Biological.
c. Chemical.
d. Natural extinction.

85. (C33) What is the *most* practical mechanical method for controlling annual and biennial weeds from early spring to midsummer?

a. Mowing.
b. Burning.
c. Mulching.
d. Cultivating.

86. (C34) What type of herbicide would be used to kill all types of vegetation by killing the plant tissues that are sprayed?

a. Contact - nonselective.
b. Contact - selective.
c. Translocative - selective.
d. Translocative - nonselective.

87. (C34) What type of herbicide is generally used for controlling grasses and herbaceous broadleafs in areas such as storage areas, lumberyards, and parking lots?

a. Contact.
b. Translocative.
c. Soil sterilant.
d. Selective.

88. (C35) At what range of pressure should spray equipment be operated to reduce drift hazards of herbicides?

a. 30 to 60 psi.
b. 60 to 90 psi.
c. 90 to 120 psi.
d. 120 to 150 psi.

89. (C35) What situation provides the *best* condition for selective control of weedy grasses growing in turf grasses?

a. The weedy grass is a perennial and the turf grass is an annual.
b. The weedy grass is an annual and the turf grass is a perennial.
c. The weedy grass is a biennial and the turf grass is an annual.
d. The weedy grass is an annual and the turf grass is a semiannual.

90. (C36) When applying herbicides, danger of drift hazards to desirable plants is reduced the *most* by using

a. nonvolatile liquid herbicides.
b. volatile dry herbicides.
c. nonvolatile liquid herbicides.
d. volatile liquid herbicides.

END OF EXERCISE

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MODIFICATIONS

Volume 8 OF THIS PUBLICATION HAS (HAVE) BEEN DELETED. THIS MATERIAL USES MILITARY FORMS, PROCEDURES, SYSTEMS, ETC. AND IS NOT CONSIDERED APPROPRIATE FOR USE IN VOCATIONAL AND TECHNICAL EDUCATION.

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56650 00 S02 8002

CHANGE SUPPLEMENT

CDC 56650

ENTOMOLOGY SPECIALIST

(AFSC 56650)

Volumes 1, 2, 3, 4, 5, 6 and 7

IMPORTANT: Make the corrections indicated in this supplement before beginning the study of Volumes 1, 2, 3, 4, 5, 6 and 7. This supplement contains both "pen-and-ink" changes and replacement pages. It is perforated and three-hole-punched so that you can tear out the replacement pages and insert them in your volumes.

Extension Course Institute

Air Training Command

CHANGES FOR THE SUPPLEMENTARY MATERIAL: 56650 00 S01 7802

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PEN-AND-INK CHANGES:

PAGE	LINE(S)	CORRECTION
✓ Cover	6	Change "Appendixes A and B" to "Appendixes A, B and C."
✓	7	After "Volumes" insert "3,."
✓ 1		Add "Appendix C. Integrated Pest Management Methods."

✓ ADDITIONAL PAGES: Insert the following additional pages: 63, 64, 65, 66, 67, 68 and 69.

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CHANGES FOR THE TEXT: VOLUME 2

PEN-AND-INK CHANGES:

PAGE-COL	SUBJECT	LINE(S)	CORRECTION
✓1L		20 from bottom	Change "they" to "humans" and "their" to "insect."
✓2L		11	Between "writing" and "these" insert "and recognizing."

On the following, change "Insecta" to "Hexapoda."

PAGE-COL	SUBJECT	LINE(S)	CORRECTION
3L		16 from bottom	
✓5	Table 1-1	Column 3, line 7	
✓6R		4	
✓7L		5 and 10 from bottom	
✓8R		9	
✓9	Exercises (204)-3		
✓9	Exercises (204)-5.e.		
✓15L		11 and 12 from bottom	
✓16R		5 from bottom	Change "*Distyoptera*" to "*Dictyoptera*."
✓16R		3 from bottom	Change "belong" to "belonging."
✓17L		8	Change "*psocoptera*" to "*Psocoptera*."
✓19L	Figure 1-29		Change "Dictyafatera" to "Dictyoptera."
✓45R		30	Change "exemplifying" to "exemplify."
✓50R		3	Change "elimiate" to "eliminate."

PAGE-COL	SUBJECT	LINE(S)	CORRECTION
✓50R		8 from bottom	Change "the" to "then."
✓51L		16 from bottom	Change "plants" to "plant."
✓51R		14	Change "low-boiling liquid" to "low-boiling point liquid."
77R		7	Change the first "to" to "the."
77R		18	Change "authoriative" to "authoritative."
77R		30	Change "and empty" to "and the empty."
81L		9 from bottom	Change "of" to "or the."
83L		15 from bottom	Change "is" to "if."
85L		10	Change "half" to "halt."
87L		6 from bottom	Change "and re-" to "and pesticides re-."
89L		30	Change "four" to "foul."
96R		15 from bottom	Change "clean" to "clear."
113	Answer 204-3		Change "Insecta" to "Hexapoda."
115	Answer 232-4		Change "Nemotodes" to "Nematodes."

CHANGES FOR THE TEXT: VOLUME 3

1R		last	Change "*stomack*" to "*stomach*."
17R		9 from bottom	Change the second "be" to "by."
19L		3 from bottom	Delete "that."
19R		1	Change "and" to "an."
20L		2	Change "distomaceous" to "diatomaceous."

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PAGE-COL	SUBJECT	LINE(S)	CORRECTION
20L		16	Change "is" to "in."
20R		19 from bottom	Change "together than" to "together, rather than."
29R		4 from bottom	Change "ration" to "ratio."
34R		5	Change "light" to "oxygen."
34R		15	Delete "a."
35L		24	Change "Phytolanktons" to "Phytoplanktons."
37L		12 from bottom	Change "tood in" to "tool for."
37R		15	Change "on" to "of."
38I		12	After "When" add "integrated."
38L		30	After "measures." add "[illegible]ee Appendix C.)."
38L		29 from bottom	Change "the" to "the[illegible]
39	Exercises (425)-4		After "If" add "integrated."
39R		19	Change "resistant" to "nonresistant."
44L		9 from bottom	Change "for particular" to "for a particular."
46L		3	Change "crack crevice" to "crack and crevice."
46L		4	Change "insects" to "pests."
47L		8	Change "insects" to "pests."
53L		24 from bottom	Change "thre" to "there."
55L		2	Change "phosphite" to "phosphide."

PAGE-COL	SUBJECT	LINE(S)	CORRECTION
60R		15 from bottom	Delete "The plunger or . . . lasting but expensive." and replace with "This pump can be used for any type of liquid formulation, withstand rough treatment, and is long lasting but expensive."
61L		1	Change "disphragm" to "diaphragm."
64L		9 from bottom	Change "filled compressed" to "filled a compressed."
69R		15 from bottom	Change "but are" to "but they are."

CHANGES FOR THE TEXT: VOLUME 4

PAGE-COL	SUBJECT	LINE(S)	CORRECTION
3R		13	Change "*Cycle-propagative*" to "*Cyclo-propagative*."
4R		13	Change "fevere" to "fever."
7L		1	Change "heartworn" to "heartworm."
14R		18	Enclose "galliniper" in quotation marks."
25R		21	Change "Deseases" to "Diseases."
25R		25	Change "desease" to "disease."
26L		13 from bottom	Change "hesstan" to "Hessian."
29R		18 from bottom	Change "full" to "dull."
30L		11 from bottom	Change "then" to "than."
38L		27	Change "*finds*" to "*kinds*."
40R		17 from bottom	Change "aprtments" to "apartments."
41L		18	Change "contains" to "containers."
48R		17	Change "presticide" to "pesticide."
50L		15 from bottom	Change "disinfection" to "disinsectization."

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PAGE-COL	SUBJECT	LINE(S)	CORRECTION
52L		17 from bottom	Change "epedemics" to "epidemics."
52R		4	Change "bilobed" to "bi-lobed."
54L		2 from bottom	Change "succomb" to "succumb."
63L		21	Change "infection" to "infestation."
67L		5	Change "englarged" to "enlarged."
CHANGES FOR THE TEXT:		**VOLUME 5**	
3L		9	Change "family" to "sub-family."
3L		10	Change "bombidae" to "Bombidae."
5	Exercises (807)-9		Change "carboryl" to "carbaryl."
5R		9	Change "*Maculata*" to "*maculata*."
6R		last	Change "amoun" to "amount."
8R		1	Change "like" to "Unlike."
10R		26	Change "*gertsdichi*" to "*gertschi*."
11L		8-9	Change sentence to read "Adult scorpions vary in length from less than an inch to almost 8 inches."
13L		6 from bottom	Change "winds" to "wings."
22L		12	Change "Dictuoptera" to "Dictyoptera."
22R		12	Delete the first "are."
24R		12-13 from bottom	Delete "It has a pale area surrounding the pronotum."
29L		29	Change "but" to "big."
36	Answer 813-4		Change "carbomates" to "carbamates."

CHANGES FOR THE TEXT: VOLUME 6

PEN-AND-INK CHANGES:

PAGE-COL	SUBJECT	LINE(S)	CORRECTION
iii	Preface	3 from bottom	Change "3 hours" to "33 hours."
3	Table 1-1	Title	Change "Assemssment" to "Assessment."
8L		10	Change "case" to "cast" and "It" to "It's."
8R		22	Change "on" to "of."
9L		5 from bottom	Change "Exercises (A08)" to "Exercises (A09)."
9R		23 from bottom	Change "in" to "is."
18L		16 from bottom	Change "don-t" to "don't."
18R		24 from bottom	Change "*Retienlitermes*" to "*Reticulitermes*."
19L		17	Change "tod" to "to."
30L		16 from bottom	Change "to" to "on."
31L		18 from bottom	Change "*Holy*" to "*Holly*."
33L		29 from bottom	Change the second "and" to "of."
34R		27 from bottom	Change "mor" to "more."
35L		3	Change "excretment" to "excrement."
41L		18	Change "hardward" to "hardware."

CHANGES FOR THE TEXT: VOLUME 7

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PEN-AND-INK CHANGES:

PAGE-COL	SUBJECT	LINE(S)	CORRECTION
1L		12 from bottom	Change "leptospirois" to "leptospirosis."
1L		4 from bottom	Change "dilling" to "killing."
1R		last	After "domestic" add "rodents will become infected, and carry the infection to humans. This disease is usually fatal to the rat, the flea, and to the human."
2R		1-3	Delete "rodents will become . . . fleas, and humans."
6L		13 from bottom	Change "builidng" to "building."
8R		10 from bottom	Change "infestation" to "infestations."
18R		13 from bottom	Change "intomologist" to "entomologist."
27R		17-24	Delete "If you have received . . . all entrances and exits."
28L		5	Delete "__11. DDT will kill bats."
48	Answer C24-11		Delete.